TECHNOLOGY DEPT.

PUBLIC LIBRARY
OCT 29 1946
DETROIT

Electronic Engineering

INCORPORATING ELECTRONICS, TELEVISION AND SHORT WAVE WORLD

PRINCIPAL CONTENTS

A New Oscilloscope with D.C. Amplification
A Timer for Photo-Printing.
Line Scanning Systems for Television
German Infra-Red Technique
Metal Rectifier Developments

2/- OCT., 1946

Paxolin Tubes and Cylinders

Because of their light weight, good mechanical and electrical properties, Paxolin tubes and cylinders were called upon during the war to do many jobs that we had never even thought about.

This meant that they were in short supply for their usual job of helping to keep electricity in its proper place. Supplies are now getting back to normal, and we are always pleased to give full particulars of Paxolin tubes and cylinders to those who would like to know more about their electrical or mechanical properties or both.

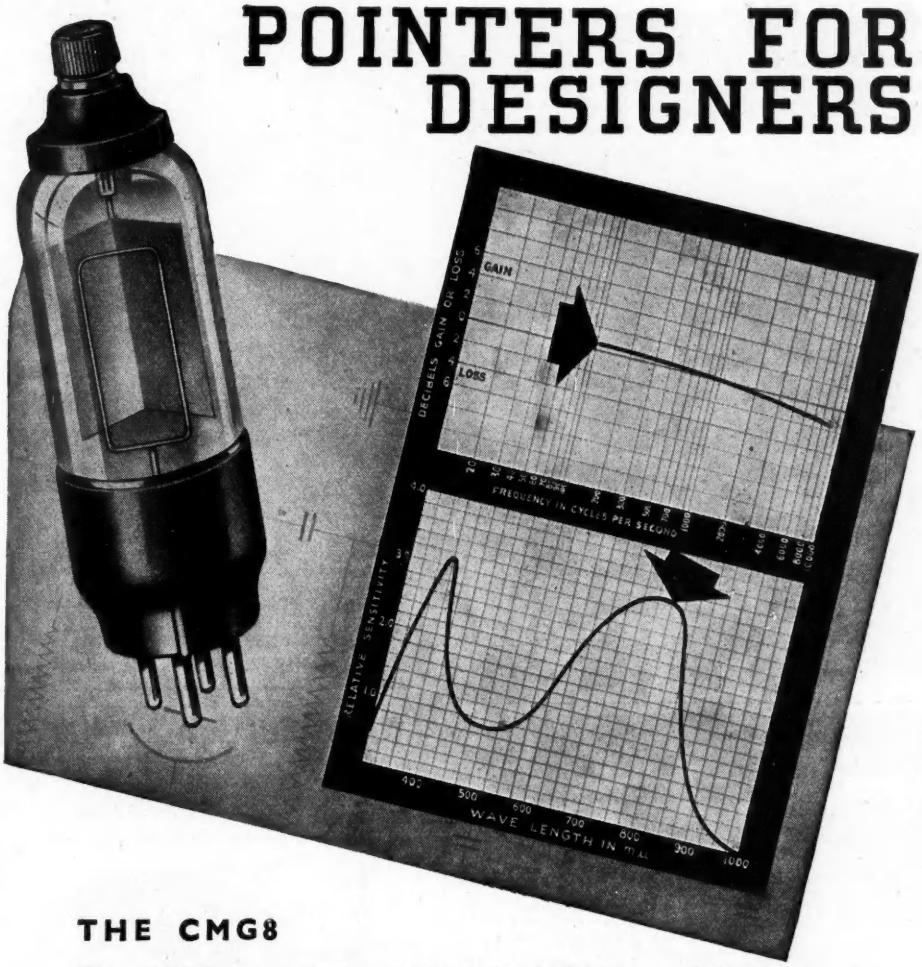
THE MICANITE & INSULATORS COMPANY, LTD.

Empire Works, Blackhorse Lane, Walthamstow, London, E.17.

m and i

Manufacturers of MICANITE (Built-up Mica Insulation). Fabricated and Processed MICA, PAXOLIN (Synthetic-resin laminated sheets, rods, tubes, and cylinders). HIGH-VOLTAGE BUSHINGS and TERMINALS for indoor and outdoor use. EMPIRE varnished Insulating Cloths and Tapes and all other forms of Electrical Insulation. Suppliers of Vulcanised Fibre, Leatheroid, Presspahn, etc. Distributors of Micoflex-Duratube Sleevings and Kenutuf Injection Mouldings (P.V.C.).

POINTERS FOR DESIGNERS



THE CMG8

The CMG 8 is a typical example of the OSRAM range of emission-type photocells which constitute the essential means of converting light changes into electric current. Widely used in sound projectors and industrial apparatus they are non-microphonic and of convenient size. Outstanding features include :—

- Linear response for sound reproduction giving undistorted output.
- High sensitivity to artificial light.

A detailed technical data sheet is available on request.

Osram PHOTO CELLS — **G.E.C.** CATHODE RAY TUBES — **Osram** VALVES

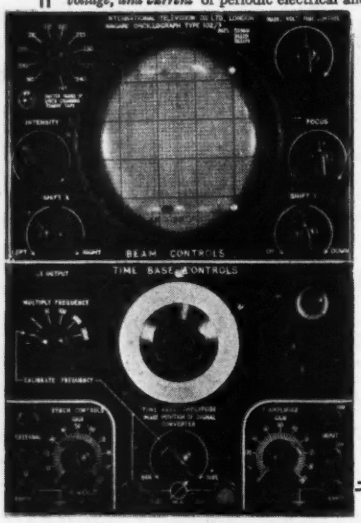
Advt. of The General Electric Co., Ltd., Magnet House, Kingsway, London, W C.2.

NAGARD TYPE 102S

OSCILLOGRAPH AND OSCILLOMETER

For universal servicing and the usual comparative measurements. **Calibrated time base velocity.** Accuracy 1 per cent. **Internal standard source of voltage** for comparative voltage measurements. Range : 0.01 v. to 200 v. Accuracy 2 per cent.

Ideally suitable **for quick** *determination of the waveform, frequency voltage, and current* of periodic electrical and mechanical phenomena.



Two-stage Y amplifier, L.F. and H.F. corrected. At 3 Mc/s response -4 db. Useful response even at 5 Mc/s. Input capacity $<14\ \mu\mu F$. Input resistance $>500{,}000$ ohms. Highest writing speed 10 millimetres per microsecond. Semi-automatic synchronisation. Perfect for photographic recording. 5" screen C.R. Tube. Effect of mains variations eliminated.

£70

INTERNATIONAL TELEVISION CORPORATION LTD.

67-69 WHITFIELD ST. LONDON, W.1.

Telephone: MUSeum 2330
Telegrams : INTERTEL, RATH, LONDON

450° is a normal working temperature for vitreous-enamelled Welwyn resistors

Such is the quality of the enamel used in Welwyn Vitreous Resistors that they will operate continuously at 450° C. This is more than twice the safe temperature for ordinary vitreous resistors.

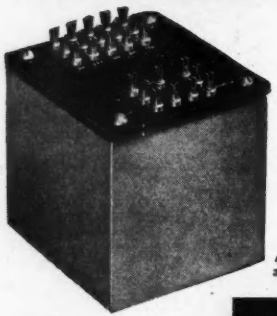
Sizes for every purpose—1 W to 300 W ; also Welwyn High Stability Carbon Resistors—$\frac{1}{4}$ W to 2 W.

New catalogue now available for Trade

WELWYN ELECTRICAL LABORATORIES LTD

Welwyn Garden City, Herts. *Telephone: Welwyn Garden 3816-8*

Power and Audio Frequency Transformers



POWER TRANSFORMERS 5VA to 5KVA Audio Transformers up to 1500 watts.

EITHER

- Open construction in a variety of mountings, windings vacuum pressure impregnated and varnished sealed.
- Canned and bitumen or wax filled.
- Hermetically sealed, oil filled, with pressure compensation.

Application : Microphone, driver, anode to line, line to line, etc.

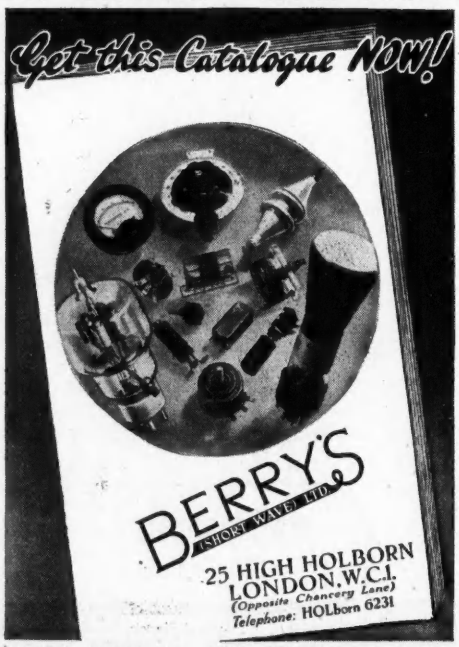
SPECIAL FEATURES

- Direct fixing to Transformer structure — no strain on container to cause distortion or leaks.
- No unsightly fixing lugs external to container.
- Male or female threads for upright or inverted mounting at will.

AUDIO TRANSFORMERS—SINGLE, DUAL OR TRI-ALLOY SHIELDED, GIVING NOISE SUPPRESSION UP TO 90 DB RELATIVE TO CONVENTIONAL OPEN ASSEMBLIES.

ASSOCIATED ELECTRONIC ENGINEERS LTD
DALSTON GARDENS STANMORE MIDDX.
Tel WORDSWORTH 4474/5/6

NEW Edition. NOW READY !



PLEASE SEND 6d. FOR POST FREE COPY

BRIMAR VALVES

FOR RADIO FREQUENCY AMPLIFICATION

TYPE 6K7G

PLANNED to cover the widest possible field of uses, the BRIMAR range will give you replacements for either British or American receivers. On this page we show valves for R.F. amplification. Equally comprehensive is the list of valves for other purposes — mixers, signal rectifiers, A.F. amplifiers, power output valves and power rectifiers.

BRIMAR VALVES FOR R.F. AMPLIFICATION

Type	*E/F*	*I/F*	*Purpose*
ENGLISH			
9A1	4	1	V.mu R.F. Pen.
9D2	13	0.2	V.mu R.F. Pen.
8A1	4	1	R.F. Pen.
8D2	13	0.2	R.F. Pen.
AMERICAN			
6C6	6.3	0.3	R.F. Pen.
6D6	6.3	0.3	V.mu R.F. Pen.
77	6.3	0.3	R.F. Pen.
78	6.3	0.3	V.mu R.F. Pen.
LOCTAL			
1LN5	1.4	0.05	Battery R.F. Pen.
7A7	6.3	0.3	V.mu R.F. Pen.
7B7	6.3	0.15	V.mu R.F. Pen.
OCTAL			
1N5G	1.4	0.05	Battery R.F. Pen.
6J7G	6.3	0.3	R.F. Pen.
6K7G	6.3	0.3	V.mu R.F. Pen.
6U7G	6.3	0.3	V.mu R.F. Pen.
12J7GT	12.6	0.15	R.F. Pen.
12K7GT	12.6	0.15	V.mu R.F. Pen.
MINIATURE			
1T4	1.4	0.05	V.mu R.F. Pen.

BRIMAR (BVA) RADIO VALVES

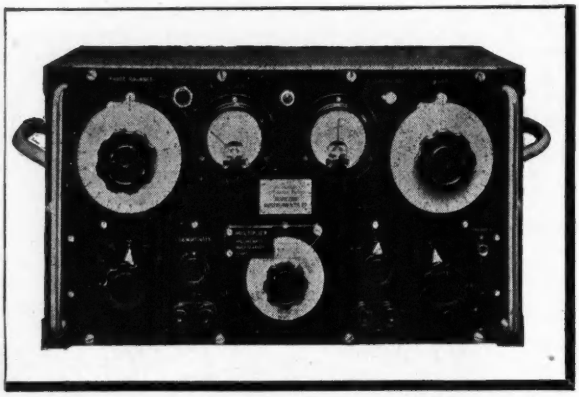
STANDARD TELEPHONES AND CABLES LIMITED, FOOTSCRAY, SIDCUP.

From its unique range of
Communications Test Gear
MARCONI INSTRUMENTS LTD
can now offer the

UNIVERSAL IMPEDANCE BRIDGE

TYPE TF 373D

FOR IMMEDIATE DELIVERY



Designed for the direct measurement of inductance, capacitance and resistance over exceptionally wide ranges, the instrument is a product of Marconi pioneer experience in radio engineering.

Full specification available on request.

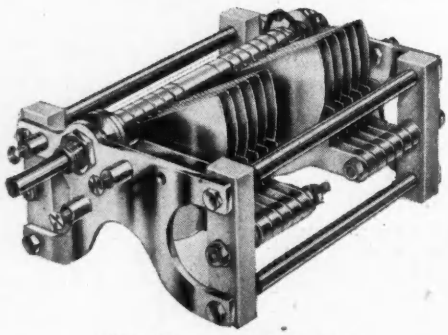
MARCONI INSTRUMENTS LTD

ST. ALBANS, HERTS. Telephone: ST. ALBANS 4323/6

Southern Office: 109 EATON SQUARE, LONDON, S.W.1. Phone: Sloane 8615

Northern Office: 30 ALBION STREET, HULL. Phone: Hull 16144 Western Office: 10 PORTVIEW ROAD, AVONMOUTH. Phone: Avonmouth 438

"Cyldon"
Transmitting Capacitors



TYPE SSTR. SQUARE LAW

Max. Capacity	*List Price*
100 pF	£1 : 7 : 6
150 „	£1 : 12 : 0
200 „	£1 : 15 : 0
250 „	£2 : 0 : 0
300 „	£2 : 10 : 0

SYDNEY S. BIRD & SONS LTD.
Cambridge Arterial Road, Enfield, Middlesex.
Phone: ENField 2071-2 *Telegrams: "Capacity, Enfield."*

FLOATING ROTOR
DOUBLE CONTACT

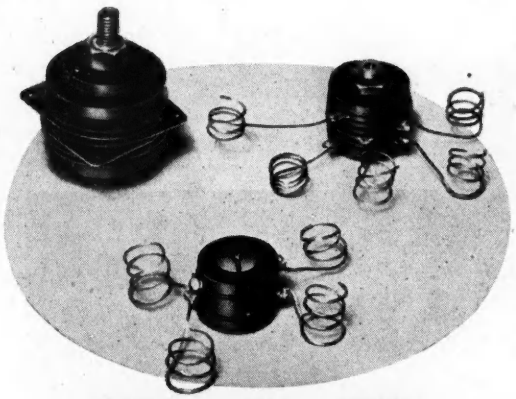
Only in the famous

OAK SWITCH

Other British N.S.F. Products include **PAPER CAPACITORS, SILVERED MICA CAPACITORS, WIRE WOUND RESISTORS AND VOLUME CONTROLS**—*Write for full details.*

Manufactured by
BRITISH N.S.F. CO. LTD.
KEIGHLEY, YORKSHIRE
London Office: 9 Stratford Place, W.1. *Tel.:* MAYfair 4234
Sole Licensees of OAK Manufacturing Co. Chicago

GA



WESTINGHOUSE

METAL RECTIFIERS

for electrical measuring instruments

requiring an input of up to 500 millivolts at currents of from 100 microamperes up to 500 milliamperes.

Full details are given in descriptive pamphlet No. M.R.3, a copy of which may be obtained from Dept. E.E.

WESTINGHOUSE BRAKE & SIGNAL CO LTD.
82, York Way, King's Cross, London, N.1.

TELCON CABLES

Supreme for Radio & Television

A complete range of High Frequency Cables with "TELCOTHENE" low loss insulation, is now available for use in the audio, radio, and electronic fields of application. Write for H.F. brochure.

TELCON

TELCON designed H.F. Cables are the basis of world standards

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD.
Founded 1864
Head Office: 22 OLD BROAD STREET, LONDON, E.C.2. Tel: LONdon Wall 3141
Enquiries to: TELCON WORKS, GREENWICH, S.E.10. Tel: Greenwich 1040

Electronic Engineering

OCTOBER, 1946

Volume XVIII. No. 224.

CONTENTS

PAGE

Editorial—A.P. 295

"Britain Can Make It" 296

A New Oscilloscope with D.C. Amplification
By J. H. Reyner, B.Sc., M.I.E.E. 297

A Timer for Photo-printing
By N. Phelp and F. Tappenden 300

Line Scanning Systems for Television
By A. M. Spooner, B.Sc., and E. E. Shelton, B.Sc. 302

A New Torque Motor
By A. E. Adams and D. Waloff 308

16-mm. Sound-on-Film Recorders
By James Neil, A.R.P.S. 309

Metal Rectifier Developments—Possible Applications of Titanium Dioxide
By H. K. Henisch, BSc., A.Inst.P. 313

Television Commentary 315

The Development of Infra-Red Technique in Germany
By V. Krizek and Dr. V. Vand, F.R.A.S., F.Inst.P. 316

Waveguide Measurements
By G. Ashdown, A.Inst.P.— 318

The Effect of Frequency in Induction Heating (abstracted)
By Dr. R. A. Neilson 320

October Meetings 322

Notes from the Industry 323

Book Reviews 324

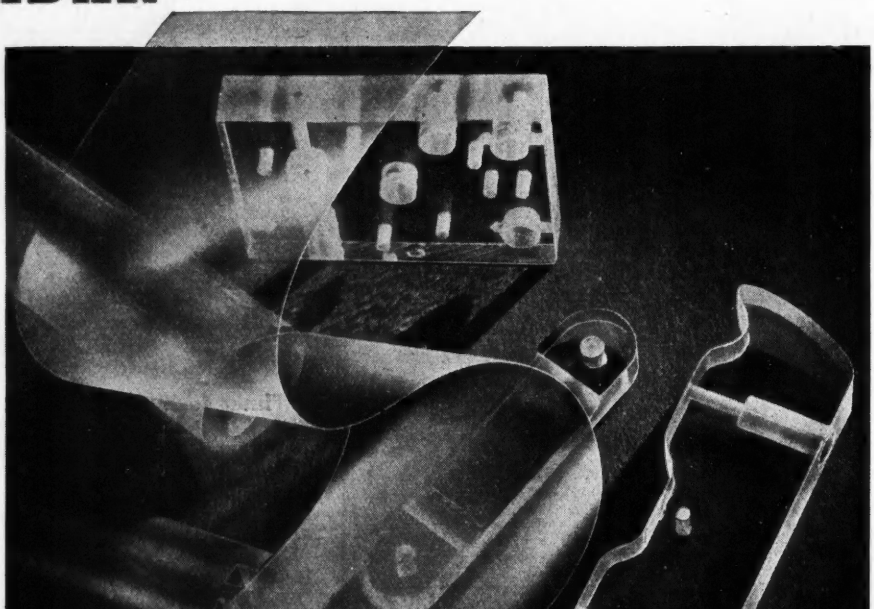
Abstracts of Electronic Literature ... 326

A Range of Miniature Vacuum Tubes ... xiv

CONDITIONS OF SALE.—This periodical is sold subject to the following conditions, namely, that it shall not, without the written consent of the publishers first given, be lent, re-sold, hired out or otherwise disposed of by way of Trade except at the full retail price of 2/- and that it shall not be lent, re-sold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade, or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

first RADAR



now DISTRENE foil

Radar, one of the most epoch-making inventions of this century, would not have been possible without the help of a material possessing a very low power factor, a high resistance to moisture and great dimensional stability.

DISTRENE Regd. (Polystyrene) was the material that completely met these needs.

Now, in the change over from war to peace, you have your problems of high-frequency radio and electrical insulation. DISTRENE FOIL can help you to surmount them.

In DISTRENE FOIL (Orientated Polystyrene Film) the molecules are specially arranged during manipulation so that the tensile strength is increased by 3 times and the flexibility by 10 times.

Power Factor
0·0002-0·0004

Tensile Strength
10,000 lbs./sq. in.

Thickness
0·001" to 0·008"

BX PLASTICS LTD LARKSWOOD WORKS · LONDON · E.4

Telephone: Larkswood 4491

Branches: King Street Buildings, 1 Ridgefield, Manchester, 2. *Telephone: Manchester Blackfriars 0258*
42 Wellington Street, Sheffield. *Telephone: Sheffield 25517*

Works: London, Manningtree and Dundee.

TAYLOR 665

PROPRIETORS :
HULTON PRESS, LTD.

Electronic Engineering

MANAGING EDITOR:
G. PARR.

EDITORIAL, ADVERTISING AND PUBLISHING OFFICES, 43-44, SHOE LANE, LONDON, E.C.4

TELEPHONE
CENTRAL 7400

Monthly (published last day of preceding month) 2/- net. Subscription Rates : Post Paid to any part of the World— 6 months, 13/- ; 12 months, 26/-. Registered for Transmission by Canadian Magazine Post.

TELEGRAMS
HULTONPRES, LUD
LONDON.

A. P.

PLANS for the future of Alexandra Palace are being considered by the Trustees, according to the Sept. 20th issue of the *Palmers Green & Southgate Gazette*. After deploring the damage to the organ, which is one of the finest in the country, the report goes on :

" Among projects which will be placed before the Trustees are a dance hall, . . . a huge ice rink ; a pleasure ground and an underground garage. A start has already been made in the move to popularise the Palace, and part of the King George suite is being converted into a palm court so that Sunday evening concerts may be given in a hotel atmosphere."

The curious part about this report is the complete absence of the word " television." It can hardly be that the Trustees have not taken into consideration the fact that the Palace is the home of television and that they have the finest ' draw ' for the public already under their roof. In converting the King George suite into a palm court, is no provision to be made for television cameras ?

It seems that here is a great opportunity to create a television centre — not of course comparable with some of the vast American projects, but of sufficient magnitude and importance to remind us that the world's first commercial television programme was broadcast from the Palace.

By allowing the public to participate in the shows, either in the palm court or by glass screening walls to the studios, the popularity of television as an entertainment will increase rapidly and, what is more important, it will be talked about.

Television has now been on the air for over three months, and in the opinion of some viewers is in danger of stagnation.

This is not the fault of the B.B.C., who do wonders with the resources at their disposal. Nor is it the fault of the manufacturers, who have a healthy waiting list for receivers.

The public is, however, still apathetic, and it is the public that wants its interest roused by being shown what it is missing. There is still a persistent rumour that the present system is temporary and that a much better one is round the corner, and if one attempts to contradict this by quoting from the Television Committee's report, the retort is " Well, anyway, I'm going to wait until the sets get much cheaper. The price is bound to come down." It is difficult to controvert this except by going into technicalities, but it would help to encourage the would-be buyer by letting him go to Alexandra Palace and see for himself what the B.B.C. is doing for his entertainment. Let the Palace be the Mecca of television viewers, with demonstration receivers and an opportunity for all to see the ' live ' show.

As a shop window, the Palace could be unique both to home and overseas buyers. Let us hope that the opportunity will be taken to make it so.

ELECTRONIC ENGINEERING MONOGRAPHS

The fourth Monograph in the series is now ready under the title :

The Gas-filled Triode and its Applications

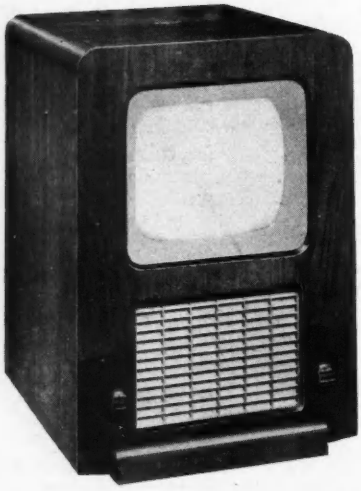
By

G. WINDRED, A.M.I.E.E.

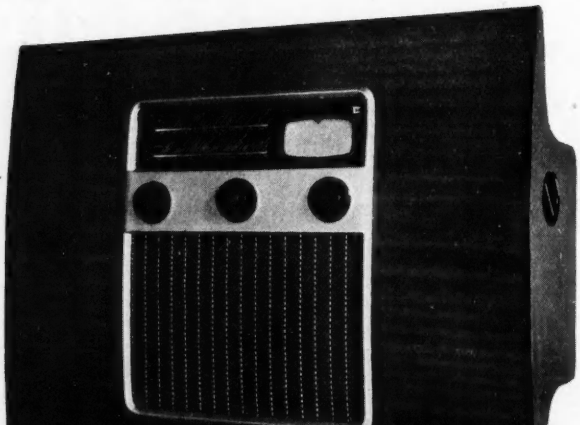
This subject is of interest to all industrial firms who have installed electronic apparatus and to those concerned in its operation and maintenance.

Copies can be obtained from Technical Booksellers, price 2s. 6d., or direct from the Circulation Dept. Hulton Press, 43 Shoe Lane, E.C.4. Price 2s. 8d. post free.

"Britain Can Make It"



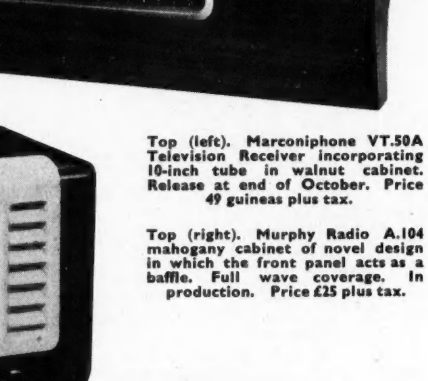
Representative Radar and Television Receivers to be seen at the 'Britain Can Make It' Exhibition held at The Victoria and Albert Museum, Kensington, London, on September 24–October 30.



Top (left). Marconiphone VT.50A Television Receiver incorporating 10-inch tube in walnut cabinet. Release at end of October. Price 49 guineas plus tax.

Top (right). Murphy Radio A.104 mahogany cabinet of novel design in which the front panel acts as a baffle. Full wave coverage. In production. Price £25 plus tax.

Centre. Ekco table model Universal Receiver Type U29. In black plastic (and other colours) with Ivory Escutcheon. In production. Price 13 guineas plus tax.



Left. H.M.V. Television Receiver. Model 1803 with 15-inch Emiscope in walnut cabinet. Release date not given.

Right. Roberts Radio portable receiver. Type P.4.D. in blue, brown or black rexine case. Three wave bands. In production. Price 14 guineas complete plus tax.

A New Oscilloscope with D.C. Amplification

By J. H. REYNER, B.Sc., M.I.E.E. and F. R. MILSOM*

THE applications of oscillograph technique are now so widespread that the designer of a general purpose instrument is in considerable difficulty as to what to include.

The range of frequency spectrum covered is an important factor in assessing the usefulness of the equipment, as the modern commercial oscilloscope may have to be used for a variety of industrial purposes or for electro-medical research in addition to the ordinary range of audio- or radio-frequency measurements.

Accordingly it was decided that the deflection amplifier should be capable of handling all frequencies from zero to the megacycle region—a requirement which necessitated a direct coupled high-gain amplifier. In addition, the following features were considered desirable:

(a) The image should be sharply defined and completely steady.

(b) Provision should be made for instantaneous positioning at any part of the screen.

(c) It should be possible to expand the trace at any part for closer examination.

(d) The various controls should be completely independent.

In the present instrument the first requirement has been met by the use of a fine focus tube (G.E.C. Type E4412) with symmetrical deflection on both axes. The definition of the tube is such that although its screen diameter is only 3½ in. a very clear image is obtained, which can be viewed either as a whole or in part by using the expansion feature.

Instantaneous location of the image at any part of the screen is attained by the use of D.C. coupling to the plates. This is the case whether the signal is applied directly to the plates or through the amplifiers because the amplifiers themselves are D.C.-coupled. Many forms of D.C. amplifier are subject to drift and if this were permitted it would clearly invalidate the advantage of the D.C. couplings. Particular care has therefore been taken to devise a circuit which is free from this trouble, so that under all conditions the image is quite steady.

* Furzehill Laboratories, Ltd.

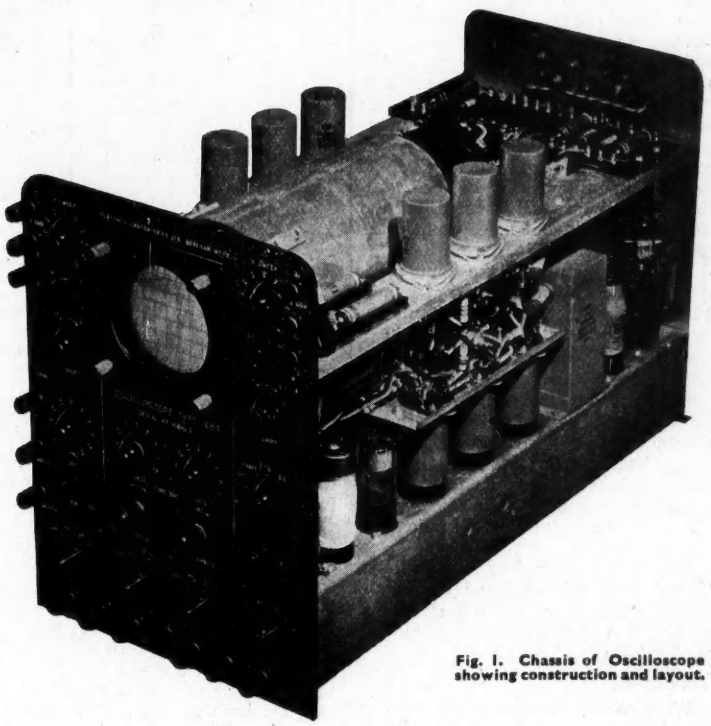


Fig. 1. Chassis of Oscilloscope showing construction and layout.

Expansion of the image is arranged by the inclusion on both axes of amplifiers capable of handling an extended sweep, as a result of which the size of the image can be varied between 0.2 and 5 screen diameters. The time base is fed into the "X" amplifier, so that this expansion feature is available under all conditions.

The fourth of the desirable features, namely freedom from interaction, is not achieved in any simple manner, but by attention to detail in various parts of the circuit. Two contributory features are that all the circuits, both in the amplifiers and the time base, are so arranged as to pass no signal current into the H.T. line. This avoids transient surges, which would otherwise be present when the position of the various controls is altered, and results in substantially complete independence. The second factor is the introduction of a limiting circuit into the synchronising amplifier, which has the effect of rendering the synchronism independent of the form and amplitude of the signal under examination, so that the image remains steady despite changes in the signal or variation of the settings of the other controls.

Reliability

Long life and consistent performance are essentials in an instrument. This requirement necessitates the departure in many respects from radio technique. In the present instrument, for example, no electrolytic condensers are used in any part of the circuit, and the components are all of tropical construction and conservatively rated. This inevitably increases the cost of production, but first cost in an instrument is usually of secondary consideration. The form of construction is illustrated in Fig. 1. The power pack and time base are housed on a

sheet-steel chassis at the bottom of the instrument. The two amplifiers, which are identical, are carried on subsidiary platforms running from front to back of the instrument, one on either side of the tube. The tube itself is in the centre, surrounded by a mu-metal shield to prevent interference with the trace by stray magnetic fields, the tube face being visible through an aperture in the front panel which is covered by a removable graticule ruled in mm. and cm. The tube mount is so designed that it can be removed and replaced by a camera, suitable for either single picture or continuous film operation, which is available as an accessory. The essential controls are all located on the front panel, conveniently grouped, as can be seen from Fig. 1.

A useful feature is the four plate selection switches on the front panel. These enable the four deflector plates to be switched individually:—

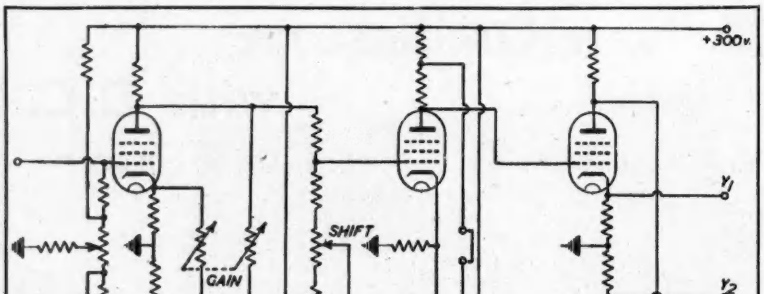
1. To the amplifier for the particular axis.
2. To terminals on the front panel, through an A.C. coupling having a time constant of 0.1 sec.
3. Direct to terminals at the rear of the instrument, enabling short connexions to be made to the plates.
4. To earth (gun) when the particular plate is not required.

The direct connexion to the plates in condition 3 is obtained through a panel at the rear of the instrument, which also provides access to the modulator electrode.

Amplifiers

We now come to a consideration of the frequency range of the instrument. There are many applications, such as strain-gauge work, electromedical work, photo-electric measurements, and so on, in which the frequencies involved may be small fractions of one cycle per second. Any form of A.C. coupling is quite inadequate for such investigations and it was decided, therefore, that the amplifiers should be D.C. coupled.

The question of the upper limit of frequency involves a choice between a number of conflicting requirements, not the least of which is the price. It is however clear that, above frequencies of a few Mc/s., oscillograph technique is changing. Much of the work at really high frequencies involves pulse circuits, and here the most satisfactory form of time base is the slave, or driven, time base. It was decided therefore to make the instrument as useful as possible up to a frequency of about 3 Mc/s., but to accept any limitations which arose.



SCREEN CONNEXIONS OMITTED FOR CLARITY

Fig. 2. Circuit of direct coupled 3-stage amplifier.

It was found that the instrument was, in fact, quite capable of looking at many of the pulses required for television work, even though it had not been specifically designed for that purpose.

Each of the amplifiers, therefore, embodies a 3-stage network, employing valves (EF.50) in a long-tail pair connexion (*see* Fig. 2). The circuiting is such that the amplifiers respond to difference of signal potential between the input terminals, being several hundred times less sensitive to variations of the potential of the two terminals together with respect to ground. The system, however, can still be used with one terminal earthy if required.

The maximum frequency is determined by the amount of power which can be developed in the output stage, having regard to the capacitance of the tube plates and the signal voltage required across them. For many purposes it is not necessary to go higher than 1 Mc/s. and the normal condition of the instrument provides a sensitivity of 8 mV r.m.s. per cm. deflection on the tube, the frequency response being level from D.C. upwards, with a slight falling off at the top resulting in a loss of 3 db at 1 Mc/s.

By simple alteration of a link in the instrument, however, the performance may be modified to provide a gain of about one-third of the normal (corresponding to a sensitivity of 24 mV per cm.), in which case the response is maintained up to 3 Mc/s.

The inter-valve coupling between the first and second stages of the amplifier is by means of a 2 : 1 potentiometer network, the bottom of which is connected to a line at a potential substantially below the normal H.T. negative. In this manner the second stage is brought to the correct operating level. Shift is conveniently introduced by altering the D.C. level of one of the channels with respect to the other by means of the potentiometer in the bottom half of the network, as shown. The anodes of the second pair are directly coupled to the grids of the third stage, which consists of two cathode-followers feeding the plates of the tube in push-pull.

Gain control is effected by means of a double-gang potentiometer, one half of which is connected to bridge the anode circuits, the other to bridge the cathodes. When the cathode resistors of the pair are made common to both valves, and the bridging resistance across the anodes is at maximum, the gain is maximum, while the converse is the case for the minimum gain condition.

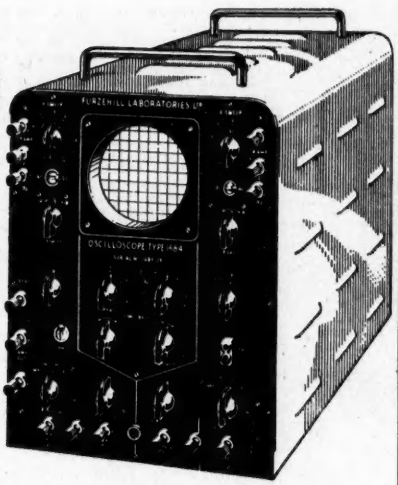
The X amplifier is identical with the Y amplifier in design, but it is normally used in the high-gain condition, since its more usual function is that of amplifying the time base sawtooth waveform. The effective sensitivity is approximately one-half that of the Y amplifier, because the X plates on the tube are less sensitive.

Time Base

The time base is of conventional design but is D.C.-coupled from the

time-base condensers to the X plates through the X amplifier. The recurrence frequency of the time base is entirely independent of the setting of the amplitude control. The length of scan is variable by this control from 0.2 to 5 screen diameters.

The frequency range is 2 c/s. to 200 kc/s., which, together with the expanding time base feature, is adequate for most investigations in the L.F. and R.F. bands. The saw-tooth time-base potential is available on the front panel of the instrument, since the time-base condensers are brought out to two small terminals there. By addition of capacitance across these terminals, the time-base recurrence frequency may be extended downwards to 0.2 c/s. These terminals may also be used to initiate the sweep when the time base is switched for single stroke operation, for which there is provision.



Front View showing grouping of controls.

Synch. Amplifier

This is a single stage associated with the time-base valves and triggers the discharge valve in the usual way. Should the signal itself be too small to lock the time-base on the work, the output of the Y amplifier is available at a terminal conveniently close to the synch. input terminal, to which it may be linked, and synch. can be obtained in this alternative manner. Employing one of these two methods, synchronisation of the time-base can be obtained on any workable signal in the sensitivity- or frequency-range of the Y amplifier.

A limiting circuit is incorporated, consisting of two metal rectifiers in back-to-back arrangement. This ensures that variation of synch.-signal amplitude cannot affect the synchronisation, while it completely avoids the sudden closing up of the image due to too large a synch. pulse. Synchronisation is obtainable on positive or negative signals.

Accessories

A camera is supplied for use with the oscilloscope, which is normally arranged for single-shot exposure. The camera is however adaptable for continuous film use in applications where the particular phenomenon is best observed by this method.

A multi-image attachment is also under development which will permit up to four phenomena to be viewed simultaneously.

Applications

It has been mentioned that the amplifiers are D.C. amplifiers and may be used as such. One particular instance of this usage is as a development aid for D.C. photo-electric amplifiers for colour monitoring. For observation of phenomena occurring at very low frequencies, 0.1 to 40 c/s. for instance, the instrument has proved invaluable, and particularly for investigations in connexion with servo mechanisms, magnetic amplifiers, etc.

Since the amplifiers are available for D.C. input connexion, there is an easy method of calibration available when using the instrument in connexion with equipment for strain and vibration measurement, for which the instrument has proved itself an excellent basic viewing unit. The same applies when using the instrument for observation of compression and explosion phenomena in engines, where a non-recurrent time-base is required. In all these uses the advantages of being able to shift the trace instantaneously to any part of the screen can be well imagined.

For L.F., R.F. and general laboratory use the instrument makes a good showing, the ease of operation and independence of controls being welcome features. As already mentioned, the instrument is capable of being used for viewing pulses. Television line synch. signals are well preserved and a satisfactory pulse-width is obtained on the screen. One-microsecond puises are very reasonably portrayed about 5 mm. in width for a recurrence frequency of 25 kc/s.

A final advantage in all applications is the high serviceability arising from the use of conservatively rated long-life components throughout.

New Glass Compositions for Industry

In a report recently issued, the British Thomson-Houston Company give a summary of the work done in the search for new glass compositions of value to the lamp and radio valve industry. Some examples are quoted below:

C.40 glass was specially designed for sealing to Kovar and Fernico type iron-nickel-cobalt alloys and the glass has been in commercial production for several months during this year, following more intermittent production during the last two or three years. The Glass Research Laboratory has co-operated very closely with several manufacturers of alloys in the development and standardisation of alloys of the Kovar type, and as a result of these combined efforts British-made alloy is now available. The availability of British alloy and glass has made possible the development and production of glass-to-metal terminal seals for use in radio equipment; valves and lamps using these materials are also now in development.

A leadless glass has been designed for sealing to iron and mild steel, and has been made successfully on a production scale. A closely similar glass has been used in the production of steel-glass "Windonuts" in which the seal between glass and metal (copper-plated mild steel) is oil tight. Experiments with new aluminosilicate glasses sealing to molybdenum, harder than any glass previously founded in a glass works, are giving interesting results in conjunction with discharge lamp design. These glasses are also useful in making chemical apparatus, particularly combustion tubing.

Of glasses melted so far only on a laboratory scale, special mention may be made of research on phosphate glasses. These alkali-free phosphate glasses are extremely fluid at very high temperatures, yet harder than borosilicate glasses at, say, 650° C. The D.C. resistivity is higher than fused silica.

Fundamental work has also been undertaken on the expansion viscosity and annealing properties of glasses; a particular effect discovered is that some borosilicate glasses change viscosity very markedly with heat treatment in a viscosity range where most glasses are rapidly stabilised.

The photograph shows the timer unit built as the baseboard of a vertical enlarger. The preset control on the left operates the standardising potentiometer, and the centre knob operates the switch selecting the discharging resistor and thence the time interval. Also on the sloping front panel are a toggle switch for sustained periods of illumination, and the operating push button. For convenience the push button control may be extended by flexible wires to any remote position. The valves are readily accessible from the side of the unit while the connexions to the mains and the lamp are brought out to suitable sockets at the back.

A Timer for Photo-Printing

By

N. PHELP and

F. TAPPENDEN*

THE apparatus described consists of an electronic switch for controlling the duration of the exposing light used for photographic printing. It allows accurately known exposing times to be given and repeated, and the operator is absolved from the necessity of listening, counting, watching, or otherwise marking the passage of time during the exposure, this leaving him free to perform any other required function.

In some scientific work it is very important to know and to repeat exposure times with a certain accuracy, which may not always be obtainable with cruder methods. Indeed, where such times are less than several seconds, it is impossible to make any exposure at all accurately if the timing is controlled subjectively. The authors have accordingly designed a simple switch unit to enable exposure times to be controlled accurately. The switch unit furthermore makes it more easy for records of exposure times to be kept .

In broad principle, the switch unit consists of a two-valve electronic switch, the operation of which is controlled by the exponentially decreasing potential difference across the terminals of a capacitance shunted by a discharging resistance. In circuit with the switch is a relay whose contacts are in series with the exposing lamp. Various different exposure times may be selected by means of a rotary switch which changes the value of the discharging resistance. Referring to the circuit diagram, the two valves constitute a switch of the type developed by T. C. Nuttall, of Cinema-Television, Ltd., and described fully in British Patent No. 552,301. The operation of the circuit is as follows:

Normally the relative potentials on the control grids of the two valves are such that the valve 10 is conducting and the valve 17 is not conducting. The grid of valve 10 is maintained at a certain fixed potential by means of the potential dividing network 1, 2, 3, through a selected discharging resistor 7. When the double-pole, double-throw switch 6 is in the position shown, a capacitor 5 is connected in shunt with the resistor 7. When the switch 6 is thrown over (in practice this is a push button key), the capacitor 5 is disconnected from its normal position in the circuit and connected in series with a small resistor across the +ve and −ve poles of the D.C. supply. On releasing the key, the switch 6 reverts to its original position so that the condenser 5 is now connected in such a way as to carry the grid of valve 10 negative with respect to its cathode. Owing to the "trigger" action of the pair of valves 10 and 17, the current flowing in the common cathode resistor 13 is forced to change over abruptly from the valve 10 to the valve 17. A relay winding 16 is included in the anode circuit of the valve 17, and as a result of the flow of current in this valve the relay 16 closes the contacts 22, thereby lighting the exposing lamp (not shown), which is connected across the terminals 25. The trigger action takes place instantaneously on releasing the key, but a delay of some few milliseconds occurs, however, before

* Cinema Television Ltd.

the operation of the relay; this delay, for practical purposes, may be neglected. The capacitor 5 is now discharged by the resistor 7, the grid potential of valve 10 continuing to rise until the relative potentials on the grids of the two valves are such as to cause another abrupt change-over of valve current, this time from valve 17 to valve 10. On the cessation of current in the anode circuit of valve 17, the relay ceases to be energised, the contacts 22 open, and the exposing lamp is extinguished. A resistor 23 and capacitor 24 are connected in series across the relay contacts 22 to quench any arc which may arise if the lamp is operated from a D.C. source. The unit is connected to suitable supply mains by way of the terminals 27.

It will be seen that the time during which the lamp is alight is determined by the time constant of the resistance-capacitance combination in the grid circuit of the valve 10, and the setting of the tapping point on the potential divider resistor 2. This latter, by fixing the normal potential on the grid of 10, determines the precise potential drop which must occur across the capacitor 5 before the switch resets itself and is used to calibrate the unit on the longest available time interval against a watch or clock with a seconds hand. A manually operated switch 26 is connected across the relay contacts 22 and may be used for exposure times longer than those catered for by the automatic unit or for operations requiring continuous illumination of the exposing lamp.

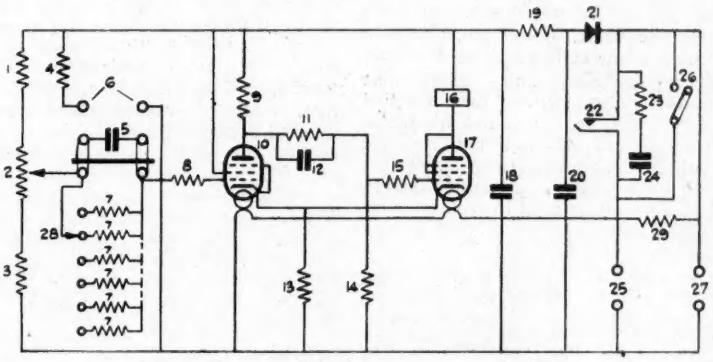
In the unit illustrated, a number of accurately known high stability resistors 7 are incorporated, any one of which may be selected by means of a rotary switch 28. The values of these resistors are chosen so as to give operation times from 1 sec. to 45 sec. with a ratio of $\sqrt{2}$ between successive steps. The steps are numbered according to the series well known in photography, and commonly applied in part to the f/ numbers of lenses.

Calibration is effected by comparing the exposure time on the longest range, *i.e.*, 45 sec., with a suitable clock, watch or seconds pendulum, and adjusting the variable resistor 2 until the required interval of 45 sec. is obtained. Slight variations in time may occur due to heating up of components and/or mains voltage variations, but these are usually of secondary importance, and the instrument can readily be checked and corrected as indicated above. It is easily possible to set the 45 sec. interval to within ½ sec. *i.e.*, within about 1 per cent. Any 50 c/s. ripple which appears on the H.T. line has two effects on the circuit which tend to reduce the accuracy. Firstly, the potential to which the capacitor 5 is charged is indeterminate to the extent of the double amplitude peak value of the ripple voltage. Secondly, the trigger action tends to be operated at a peak of this ripple which may introduce an error of up to 20 milliseconds. In practice, the ripple is reduced to such a magnitude that neither of these effects is appreciable.

This particular unit is equally suitable for use on either A.C. or D.C. mains, as the valve heaters are connected in series with a suitable resistor 29 across the mains supply terminals. This feature limits the available H.T. voltage to about 200 v. after smoothing by the resistance-capacitance network 19, 18.

Some care has been exercised in the choice of values for the trigger circuit elements so as to avoid the action taking place at a part of the discharge curve where the slope is very low. The capacitor 5 is of good quality and its capacitance should be kept low so that its insulation resistance is high in order to limit the shunting effect on the discharging resistance. A low value of capacitor, however, involves the use of high values of resistors, in order to obtain fairly long time intervals, and such resistors are not as a rule obtainable with any high degree of stability. A compromise is, however, effected by limiting the resistor value to not more than 2 megohms as these are easily obtainable with the accuracy and stability required. This does not involve the use of a capacitor of such high value as to have any appreciable detrimental effect. In the instrument described, two separate valves have been used, but it should, of course, be possible to combine them in one envelope, thus utilising a class of valve which is already enjoying considerable popularity.

This timer has been in use for some considerable time and has proved extremely valuable as a darkroom fixture, although its use is not confined to photographic exposures. Any electrical process requiring operating times covered by the unit can readily be controlled either directly from the relay incorporated in the instrument or from a subsidiary relay if greater power handling capacity is required.



1. Resistor 330 KΩ
2. Resistor 20 KΩ
3. Resistor 68 KΩ
4. Resistor 500 Ω
5. Capacitor 8 μF
6. Switch D.P.D.T.
7. See below
8. Resistor 5 KΩ
9. Resistor 20 KΩ
10. Valve EF50
11. Resistor 330 KΩ
12. Capacitor 100 μμF
13. Resistor 8 KΩ
14. Resistor 62 KΩ
15. Resistor 200 Ω
16. Relay 5,000 Ω
17. Valve EF50
18. Capacitor 8 μF
19. Resistor 3 KΩ
20. Capacitor 8 μF
21. Rectifier H75
22. Relay contacts
23. Resistor 200 Ω
24. Capacitor 0.01 μF
25. Lamp terminals
26. Toggle switch
27. Mains terminals
28. 12-way switch

Time in Seconds	Value of 7	Time in Seconds	Value of 7	Time in Seconds	Value of 7	Time in Seconds	Value of 7
1	40 KΩ	2.8	113 KΩ	8	320 KΩ	22	900 KΩ
1.4	56.6 KΩ	4	160 KΩ	11	452 KΩ	32	1.28 MΩ
2	80 KΩ	5.6	226 KΩ	16	640 KΩ	45	1.8 MΩ

Line Scanning Systems for Television

An investigation into the Efficiency and Power Demand of Deflecting Systems, with particular reference to Scanning Coils

By A. M. SPOONER, B.Sc.,* and E. E. SHELTON, B.Sc.*

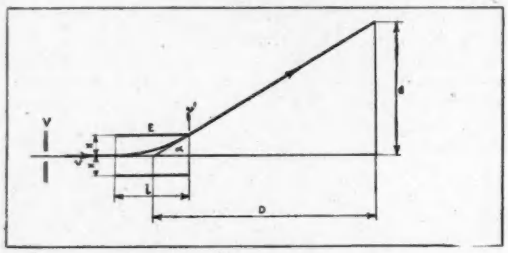


Fig. 1. Electrostatic deflection of beam.

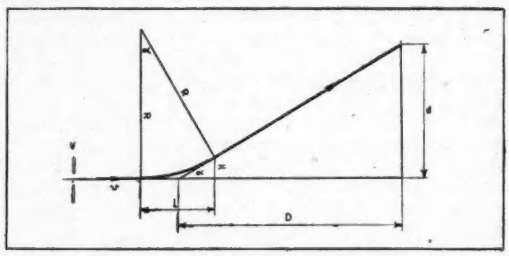


Fig. 2. Magnetic deflection of beam.

WHETHER a television picture tube beam be deflected electromagnetically or electrostatically, it is desirable to design the deflecting system (coils or plates, respectively) for maximum efficiency and minimum power demand on the driving circuit. In an ideal system, no power would be necessary in either case, since the electron beam is practically inertialess, and the energy fed to the deflecting system to cause the spot to travel across the screen would be fed back to the driving circuit during the flyback stroke. In practice, the valve whose anode is connected to the coils or plates is cut off during flyback, and during this period (10 per cent. of the total line period) the energy stored dissipates itself as heat through any resistive paths and as transformer losses if a line transformer is present, although a diode may be used to reclaim some of this energy by generating a high tension voltage.

In the following treatment, the figure of merit of the coils or plates is considered to be the ratio of useful to total flux (electromagnetic and electrostatic respectively), fringing being ignored in each case. In the electrostatic case, this is equivalent to the ratio of the capacity between the approximately triangular or trapezoidal area of each plate bounded by the extreme paths of the electron beam, and the total capacity effectively across the plates. This total capacity includes that of the plates themselves, the leads both inside and outside the tube, and the valve anode (assuming that an amplifying stage is used) and is of the order of ten times the deflector plate capacity, so that variations in plate design will have a small effect only on plate figure of merit. The figure of merit in the electrostatic case will therefore not be considered quantitatively.

In the electromagnetic case, all the inductance is concentrated in the coils, and making the assumption that a uniform field exists between them in the deflecting zone, it is possible to derive a formula for their figure of merit. The derivation of formulæ for power demand depends on different assumptions in the two cases. Electromagnetically the deflection coil is predominantly inductive, and the resistance may be ignored during the useful (slow) part of the line scan. Electrostatically, the deflection voltage is developed across a resistance to which the deflection plates are connected, and at television line deflection frequency (for 405 lines) the reactance of the total capacity is small compared with the resistance load, and may be ignored.

Electrostatic Case

Consider the path of an electron deflected (as shown in Fig. 1) by plates of length l, and distance of separation $2x$. Distance from centre of deflection system to screen is D, and deflection of spot from position of rest on screen is d. Anode to cathode voltage is V, and deflector plate voltage E.

The axial velocity of the beam is v, such that

$$\tfrac{1}{2}mv^2 = eV \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where m is the electronic mass
e is the electronic charge.

The transverse velocity of the beam on leaving the plates is:

$$v' = \frac{E}{2x}\cdot\frac{e}{m}\cdot\frac{l}{v}$$

$$\text{Then } \alpha \approx \tan\alpha = \frac{d}{D} = \frac{v'}{v} = \frac{Eel}{2xmv^2}$$

$$\text{Hence } \alpha = \frac{El}{4Vx}$$

$$i.e., \quad E = \frac{4Vx\alpha}{l} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The voltage E is considered to be developed across a valve load resistance of value Z. Hence:
Time base watts

$$W = \frac{E^2}{Z} = \frac{1}{Z}\left(\frac{4Vx\alpha}{l}\right)^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

For a numerical example take:

$V = 6{,}000$ volts.
$\alpha_{max} = \tan^{-1}(\frac{1}{4})$.
$l = 4$ cm.
$x = \frac{1}{2}$ cm.
$Z = 1$ megohm.

$$\text{Then } W = \frac{1}{10^6}\left(\frac{4 \times 6{,}000 \times 1 \times 1}{4 \times 2 \times 4}\right)^2$$

watts.

$$= 0.56 \text{ watt.}$$

In practice the beam must be of finite size to obtain sufficient current in the beam, the limit being set either by interception by the plates or by deflection defocusing. Suppose the beam has radius r_1 where it enters the deflecting plate zone, and that r_1 may be $1/A$ times the half-separation of the plates (x) before either interception of the beam or deflection defocusing becomes noticeable, and let the current density of the beam in the same region be ρ corresponding to the

* Mullard Radio Valve Co.

maximum beam current i.

Then $i = \pi r_1^2 \rho$ ..... (4)

$$r_1 = \frac{x}{A}$$

$$x^2 = A^2 r_1^2 = \frac{A^2 i}{\pi \rho} \quad \text{..... (5)}$$

and from (3):

$$W = \frac{i}{\pi \rho Z}\left(\frac{4VA\alpha}{l}\right)^2 \quad \text{..... (6)}$$

Examination of the Separate Factors

To keep the necessary time base watts as low as possible, the circuit designer keeps the value of Z as high as possible consistent with correct operating conditions of the output valve and the effect of capacity across Z on the waveform. The value of α should be low; this implies a long tube for a given picture size, a condition which depends on the greatest depth of the receiver cabinet which can be tolerated.

The cathode-ray tube designer must aim to get ρ large and A small; l cannot be increased indefinitely because of beam interception, and in practice the spacing of the plates increases towards the screen, and so extra length does not increase sensitivity proportionately. Most tubes use plates about 4 cm. long, and 6 cm. is about the useful limit.

Electromagnetic Case

In Fig. 2 an electron passing down the tube is accelerated according to Equation (1), as for the electrostatic case.

Over the length of path l, a magnetic field of strength H acts at right angles to the plane of the diagram. The path within the field is a circular arc of radius R given by:

$$\frac{mv^2}{R} = Hev \quad \text{..... (7)}$$

Introducing (1) into (7), we have:

$$R = \frac{mv}{eH} = \frac{\sqrt{2Vm/e}}{H} \text{ e.m.u.} \quad (8)$$

or $R = 3.36\sqrt{V}/H$ ..... (9)

if V and H are in practical units.

Let the resulting angle of deflection be α (an examination of commercial television tubes shows that the value of α_{max} ranges from 17° to 25° for deflection from the centre of the screen to the end of the central line). It will be assumed that the approximation $\alpha \approx \sin\alpha \approx \tan\alpha$ is of sufficient accuracy considering that field fringing is ignored.

Thus we may write:

$$\alpha = \frac{l}{R} = \frac{d}{D} = \frac{2x}{l} \quad \text{..... (10)}$$

The flux causing deflection is that through the area bounded by the axis and the extreme path of the beam:

$$\phi_d \approx H\frac{xl}{2}$$

From (10):

$$\phi_d = \frac{x}{2} HR\alpha$$

From (9):

$$\phi_d = \frac{3.36}{2}\sqrt{V}.x\alpha = 1.68\sqrt{V}.x\alpha \quad (11)$$

The inductance (including mutual) of the deflecting coils, L, is equal to the flux linkages though them due to the passage of unit current.

For a total number of turns N, a current I, and a total flux ϕ_t:

$$L = \phi_t \frac{N}{I} \quad \text{..... (12)}$$

or, putting L and I in practical units:

$$\phi_t = \frac{L}{N}.I.10^8 \quad \text{..... (13)}$$

The figure of merit of the coils is then taken as:

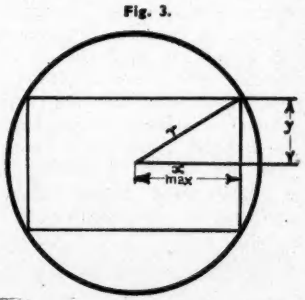
$$\eta = \frac{\phi_d}{\phi_t} = 1.68\frac{\sqrt{V}.x\alpha}{I}\left(\frac{N}{L}\right)10^{-8} \quad \text{... (14)}$$

i.e.,

$$I = \frac{1.68\sqrt{V}.x\alpha}{\eta}\left(\frac{N}{L}\right)10^{-8} \quad \text{..... (15)}$$

To arrive now at an expression for time base watts we require to consider the total change of current in the deflecting coils to sweep the electron beam from one end of the line to the other. Calling this current I_{max}, we have:

Fig. 3.



$$I_{max} = 2I \quad \text{..... (16)}$$

If the beam is swept completely across the line in T seconds, then the time base watts are equal to the stored energy divided by T, *i.e.*:

$$\text{Time base watts, } W = \frac{1}{2}\cdot\frac{L}{T}.I_{max}^2 \quad (17)$$

and substituting for (16) in (17):

$$W = \frac{2LI^2}{T} \quad \text{..... (18)}$$

Substituting for I from (15):

$$W = \left(\frac{2.38x\alpha}{\eta}\right)^2 \frac{N^2}{L}\cdot\frac{V}{T}.10^{-16} \quad \text{.. (19)}$$

To obtain the expression for time base watts for the maximum scan condition, *i.e.*, when the end of the neck just intercepts the beam at each corner of the picture, let us take the usual aspect ratio $\frac{y}{x_{max}} = \frac{4}{5}$ (*see* Fig. 3).

Then r, the internal radius of the tube neck, is:

$$r = x_{max}\sqrt{\frac{5^2 + 4^2}{5^2}} = 1.28x_{max} \quad (20)$$

Substituting (20) in (19) gives (for maximum scan):

$$W = \left(\frac{1.86r\alpha_{max}}{\eta}\right)^2 \frac{N^2}{L}\cdot\frac{V}{T}.10^{-16} \quad (21)$$

This expression is suitable for numerical checking as η and $\frac{N^2}{L}$ can be found by measurement and calculation, as will be shown later.

For a numerical example take

$V = 6{,}000$ volts.
$\alpha_{max} = \tan^{-1}(\frac{1}{4})$.
$T = 10^{-4}$ sec.
$r = 1.5$ cm.

For an actual coil for which it was found $\eta \approx \frac{1}{4}$, the number of turns was $N = 500$ and the measured inductance $L = 6$ mH:

$$W = \left(\frac{1.86 \times 1.5 \times 4 \times 500}{4}\right)^2 \times \frac{6{,}000 \times 10^{-16}}{6 \times 10^{-3} \times 10^{-4}} = 1.95 \text{ watts.}$$

This is rather less than the watts in the actual time base since losses in the transformer and the coil resistance have been neglected above, but this example is sufficient to indicate the order of the time base watts required.

Fig. 4. Light output v. Anode Voltage.

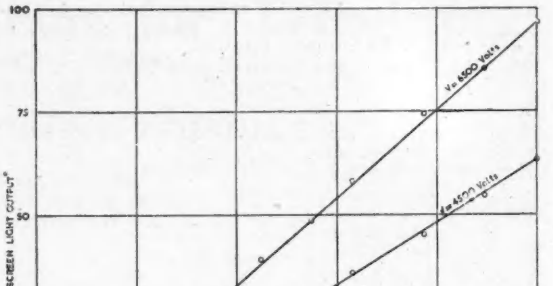


Fig. 5. Light output v. Beam Current.

No inference can be drawn from (21) concerning the dependence of time base watts on r or a because N^2/L involves geometrical factors.

F. E. Terman* gives an approximate expression for the inductance of a rectangular coil of rectangular cross-section:

$$L = lN^2G \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (22)$$

in which G depends on the ratio of coil width to coil length and on the ratio of winding cross-section dimensions to coil length; values for G are given in graphical form by Terman in Fig. 21 on page 57. We shall adopt this formula for L although the ends of our line scan coils are bent to the curvature of the neck, so that an approximation is involved here.

Substituting (22) in (21) gives:

$$W = \left(\frac{1.86ra_{max}}{\eta}\right)^2 \cdot \frac{V}{lGT} 10^{-16} \quad \ldots\ldots \quad (23)$$

The quantities r; x; l; a, are not independent of one another but are connected by Equations (10) and (20):

$$a_{max} = \frac{2x_{max}}{l} \quad \ldots\ldots\ldots\ldots\ldots \quad (10a)$$

$$r = 1.28x_{max} \quad \ldots\ldots\ldots\ldots\ldots \quad (20)$$

hence any two of a; l; and r may be treated as independent quantities and the remaining one is then dependent, and Expression (23) may be put into five different forms if desired, the most useful being that taking a and r as independent variables:

$$W = \frac{2.23\ r\ a_{max}^2\ V}{\eta^2\ G\ T} \cdot 10^{-16} \quad \ldots\ (24)$$

From this expression it may be seen that W increases with tube neck radius. This, however, is deduced for a beam of radius of cross-section negligible compared with the tube neck radius, which is not a practical case, as the beam current (and therefore the picture brightness) would be vanishingly small, or else the current density in the beam would have an impossibly high value.

In a practical case, the beam must be of finite size, and the first practical limitation reached in enlarging the beam cross-section, or in decreasing the size of the coils, is deflection defocusing. The cathode-ray tube designer must make the beam fill the maximum possible cross-section of the deflecting zone without the introduction of perceptible deflection defocusing.

Let us consider that the deflection coils are of constant proportions or form, that they conform closely to the tube neck, that the tube neck radius varies, and that the radius of the electron beam r_2 at the deflection zone may be a certain fraction $1/A$ of the neck radius r at the end of the tube neck before deflection defocusing is just appreciable.

$$\text{Then } r_2 = \frac{r}{A} \quad \ldots\ldots\ldots\ldots\ldots \quad (25)$$

Let the current density in the beam in the deflection zone be ρ corresponding to the maximum beam current i:

$$\text{Then } i = \pi r_2^2 \rho = \frac{\pi r^2 \rho}{A^2} \quad \ldots\ldots\ldots \quad (26)$$

$$\text{or} \qquad r = A\sqrt{\frac{i}{\pi\rho}} \quad \ldots\ldots\ldots\ldots \quad (27)$$

Substituting (27) in (24)

$$W = 2.23\frac{A}{\eta^2}\sqrt{\frac{i}{\pi\rho}}\cdot\frac{a_{max}^2\ V}{G\ T} \cdot 10^{-16} \quad (28)$$

Examination of the Separate Factors

T is fixed by the line repetition frequency and is not under control by the tube and circuit designer. It is worth noting, however, that the wattage demand on the high-frequency time base would be lower if the scanning were performed vertically, for although T would be reduced by (5/4) at the same time a^2 would be reduced by $(5/4)^2$ and so W would be reduced by a factor of $(5/4)^2$, which is approximately 1.6. Also, as T for the frame is over 200 times greater than for the line time base, it is clear why the wattage demand is so much easier to meet in the frame time base.

ρ the current density near the coils, corresponding to the maximum beam current for peak "white" on the picture, must be kept as high as possible by the cathode-ray tube designer. This depends on the current density available from the cathode and on the gun design.

* "Radio Engineers' Handbook," 1943 (McGraw-Hill), p. 63.

A must be kept small, that is to say, the cathode-ray tube designer must fill the largest possible cross-section of the deflecting zone, and a desirable factor in the coil design, is that it shall accept as large a beam as possible without deflection defocusing.

$V\sqrt{i}$. Picture brightness clearly depends on this product in some way, and the dependence can only be determined experimentally.

Fig. 4 shows screen light output plotted against anode voltage for several chosen beam currents, while Fig. 5 shows screen light output against $\sqrt{i}$ for several chosen anode voltages. These results are averaged from six tubes made with mixed sulphide powders giving "subjective white" television screens. As the range of current is somewhat limited, results published by Levy and West,* are replotted for comparison in Fig. 6 on a scale of abscissae giving $\sqrt{i}$. It can be seen from our Fig. 4, and from Figs. 1 and 3, in Levy and West's paper that the plots between screen light output and anode voltage are (for our purpose) nearly straight lines with an intercept on the voltage axis of very roughly 1,000 volts (referred to in the literature as the "dead" voltage).

Fig. 5 shows that screen light output is proportional to $\sqrt{i}$ over the range 30 to 100 μA, while Fig. 6 extends this up to 200 μA but shows that the brightness falls below proportionality in the 200 to 300 μA range.

There is therefore a considerable range over which designers may choose tube anode voltage and peak beam current for a fixed time base wattage and peak white brightness. If, however, a high brightness is required, it becomes advantageous to use a high voltage rather than a high peak beam current to achieve this (i) because of the "dead" voltage and (ii) because of the flattening of the $\sqrt{i}$ curve above 200 μA. (N.B.—there are other factors not dealt with here, which also weight the choice in the same direction, *e.g.*, the increase in spot size with increase of beam current and decrease of anode voltage.)

a^2. The time base watts rise very rapidly with increase of angle of deflection, so this point needs no emphasis. Deflection defocusing also increases with a. If the distance from coil to screen is increased, it means an increase in cabinet size, so the compromise here is between receiver size and time base watts.

η^2. This factor cannot be calculated, although it is fairly easy to see that η cannot be greater (with a cylindrical neck) than $\frac{1}{2 \times 1.28} = 0.39$.

The determination of η in practical cases can be made as described in the following section

The Experimental Measurement of Coil Figure of Merit

In order to derive the figures of merit for various deflection coils, use will be made of Equation (14), *i.e.*:

$$\eta = \frac{1.68\sqrt{V}xa}{I}\left(\frac{N}{L}\right)10^{-8} \quad \ldots\ldots \quad (14)$$

* "Fluorescent Screens for C.R. Tubes for Television and other Purposes." *J.I.E.E.*, Sept. 1936. p. 157 Fig. (2).

Fig. 6. Screen c.p. against beam current showing flattening of curve above 200 μA.

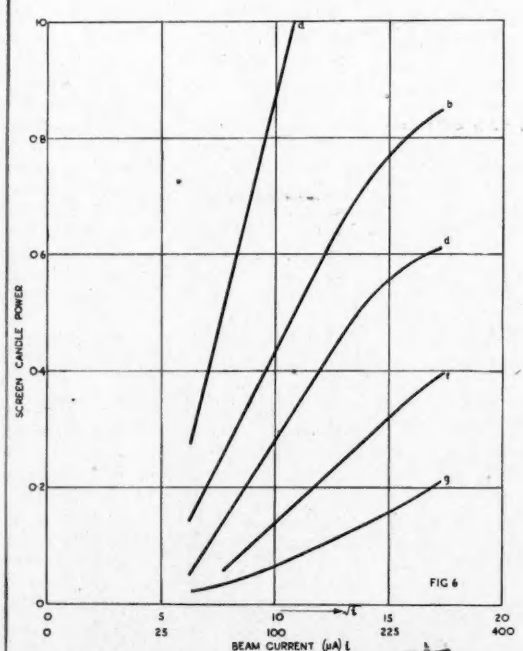


Fig. 7. Type of coil used for investigations.

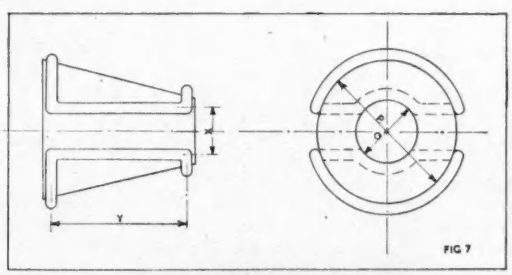
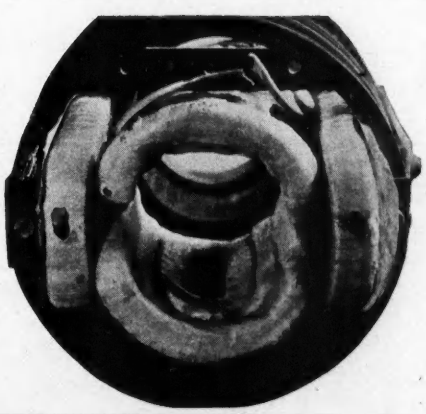


Fig. 8. Philips line coil assembly.



This may be restated in a more convenient form for the present purpose if we put

$$\text{Sensitivity } S = \frac{d}{I} \text{ (cm./amp.)} \quad \ldots\ldots (29)$$

$$a = \frac{d}{D} \quad \ldots\ldots (10)$$

$$r = 1.28\, x_{max} \quad \ldots\ldots (20)$$

Hence, substituting (29), (10) and (20) into (14), we have:

$$\eta = 1.317 S \left(\frac{N}{L}\right) \frac{\sqrt{V}}{D} \cdot 10^{-8} \quad (30)$$

Thus, for a picture tube of given length D and with constant applied anode voltage V, the essential measurements for the calculation of the figure of merit of any coil used with that tube are (i) deflection sensitivity (S), (ii) ratio of number of turns to effective inductance (N/L) and (iii) the internal radius of the tube neck (r).

For investigating the variation of figure of merit with coil design, "open" coils of the type shown in Fig. 7 were used since they are easier to construct than the "closed" type in which the whole space is filled with windings, as with the type of Philips line coil assembly shown in Fig. (8), on which measurements were also made for comparison purposes. Although the "open" variety are shown to have a lower figure of merit than the "closed" variety, they may be used for investigating other effects.

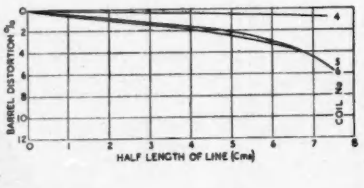
All the coils were wound on wooden jigs and taped up to give a circular cross-section of wires; they were then laid on prepared cylindrical or conical presspahn forms) bent to the shape of the forms, and taped on. The wire diameter (0.35 mm.) and the total number of turns (160) were made the same for all the coils in conformity with the outer of the three concentric "packets" used for the Philips coil. Fig. 7 gives the important dimensions, which are referred to in Table 1.

The tests could have been carried out very conveniently using an apparatus generating a grid of dots on the picture tube screen,* in that pincushion or barrel distortion and deflection defocusing could be shown together very nicely in this way. This involves, however, using a perfectly linear time base, and introduces the complication of a line time base transformer which should really be redesigned to suit each type of deflection coil system. This method was therefore not used.

The value of S was measured for the various coils used on a Mullard MW 22-1 picture tube, the coils being fed from a 50 cycle per sec. variable voltage supply. The sensitivity is the ratio of the horizontal deflection on the screen divided by the corresponding (peak) current. A pair of frame coils fed from D.C. was used to deflect up or down the horizontal line formed on the screen by the line coils, giving a measurement of pincushion and barrel distortion as the change in the length of the horizontal line with vertical deflection.

Readings of effective inductance were made, using a Q meter, with the coils clamped on the neck of the tube.

Fig. 9. Barrel distortion with coils Nos 4,5 and 6



* Cathode Ray Tube Quality Measuring Apparatus." A. M. Spooner. *Electronic Engineering*, Sept. 1946

Table 1

Coil Type No.	Coil dimensions (cm.) see Fig. (7) P	Q	X	Y	Coil assembly description	Total No. of turns, N	Effective inductance L (Henries)	Neck Radius r (cm.)	Sensitivity S* (cm./amp.)	Figure of Merit† η	Barrel distortion
1	3.5	3.5	1.0	5.0	Philips	502	0.0078	1.5	42.5	0.220	Nil
2	3.5	3.5	1.0	5.0	Small, square ...	160	0.00156	1.5	14.05	0.116	Nil
3	3.5	3.5	1.75	5.0	Small, rectangular	160	0.00132	1.5	13.5	0.131	Nil
4	8.5	8.5	3.5	10.0	Large, square ..	160	0.00355	4.0	10.85	0.105	See Fig. 10
5	8.5	5.5	3.5	10.0	Large, trapezoidal	160	0.00346	4.0	14.83	0.147	See Fig. 10
6	8.5	3.5	3.5	10.0	Large, triangular	160	0.00302	4.0	15.85	0.180	See Fig. 10

* For $V = 6{,}500$ volts.

† $\eta = 1.31 \frac{\sqrt{v}\, r\, S}{D} \left(\frac{N}{L}\right) \cdot 10^{-8} = 5.35\, r\, S\, (N/L)\, 10^{-8}$ when $D = 19.75$ cm. and $V = 6{,}500$ volts.

Table 1 shows the results of these measurements for a number of different pairs of coils, together with the figures of merit derived therefrom.

The following subheadings indicate the different design factors considered:

(i) *"Closed" versus "Open" Coils.*—Types 1 and 2 respectively are examples of these two types, Type 2 being identical approximately with the outer of the three concentric packets of which Type 1 is composed. The two resultant figures of merit show, on comparison, that it is highly desirable to fill up the centre of the coil with windings.

(ii) *Extent to which the coils wrap round the neck of the C.R. tube.*—Coil Type 3 differs from Type 2 only in that the separation of the parts of the two coils parallel with the picture tube axis is greater for Type 3 than for Type 2. This reduces the sensitivity slightly less in proportion than the effective inductance, giving a slight improvement in figure of merit.

(iii) *Trapezoidal coil system.*—Use of such x system will obviously result in a reduction of the "dead" flux in the deflecting zone, with a resulting increase in figure of merit (*see* Table 1). Unfortunately, barrel distortion (*see* Fig. 9) is introduced in this system.

It was considered desirable to carry out all tests on the same picture tube, so that to investigate this effect the actual neck diameter was not altered, but large trapezoidal coils having a minimum end separation at one end equal to the neck diameter, were made up. It is assumed that if a tube were made with a shaped neck to fit the trapezoidal test coils, then the larger end of the internal radius of the neck would be increased from 1.5 cm. to 4.0 cms., these dimensions allowing for a glass wall thickness of 2.5 mm. in each case.

An interesting further proposal on the lines of (iii) above, is to modify the shape of the end of the neck of the C.R. tube over a length of about one quarter of the coil length, so that it has a rectangular section where the beam emerges from the deflecting zone. The lower half of the diagram in Fig. 10 represents an axial section in the plane of the diagonal of the picture when the neck has been enlarged to a pyramid shape with a

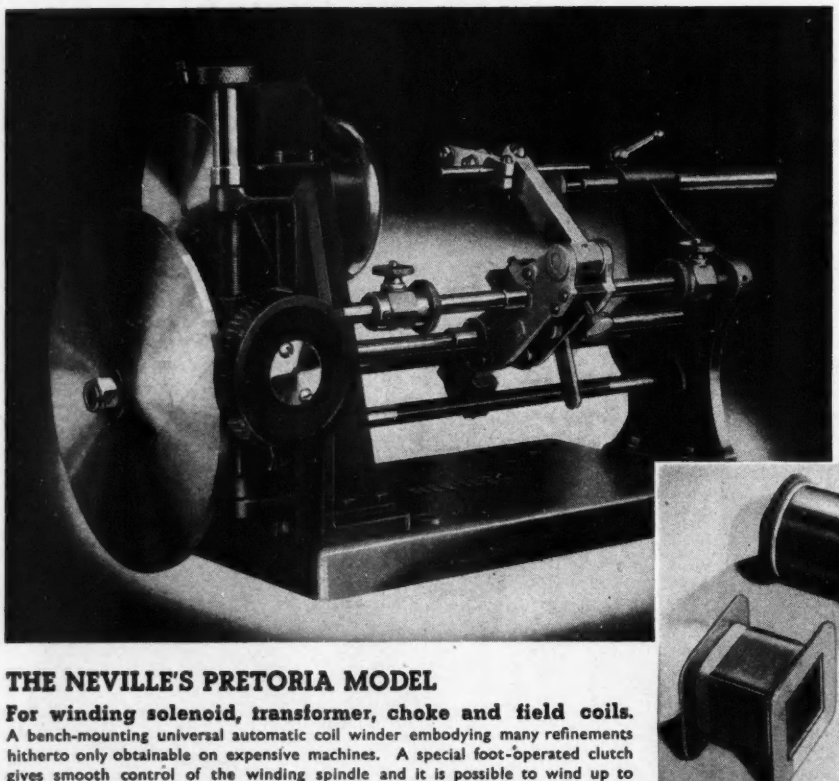
TCC CAPACITORS

PAPER
ELECTROLYTIC
MICA
SILVERED MICA
CERAMIC

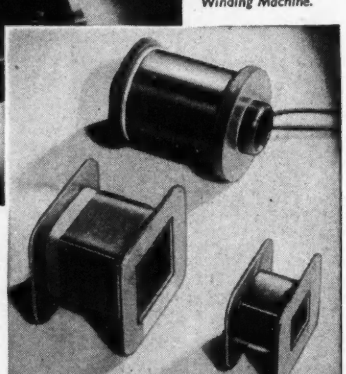
Capacitor Specialists for over 40 years

THE TELEGRAPH CONDENSER CO. LTD.
RADIO DIVISION
NORTH ACTON · LONDON · W·3 *TELEPHONE:* ACORN 0061

Coil winding MACHINES



A typical selection of coils wound on the Neville's Pretoria Coil Winding Machine.



THE NEVILLE'S PRETORIA MODEL

For winding solenoid, transformer, choke and field coils.

A bench-mounting universal automatic coil winder embodying many refinements hitherto only obtainable on expensive machines. A special foot-operated clutch gives smooth control of the winding spindle and it is possible to wind up to four coils simultaneously.

CAPACITY : Coils from 3/16" to 6" in length. Gauges of wire 22—48 S.W.G.

DIMENSIONS : The machine is 23½" long, 10" wide and 12" high.

DRIVE : 1/4 H.P., 1425 R.P.M. Electric Motor.

SPINDLE SPEEDS : 400, 530, 800, 1250, 3000, R.P.M.

Write to department EG for full particulars. An experienced staff are available to give individual attention to any coil winding problems. Your enquiries are invited.

NEVILLE'S (LIVERPOOL) LTD

THE SIMMONDS TOWER · GREAT WEST ROAD · LONDON

A COMPANY OF THE SIMMONDS GROUP

3

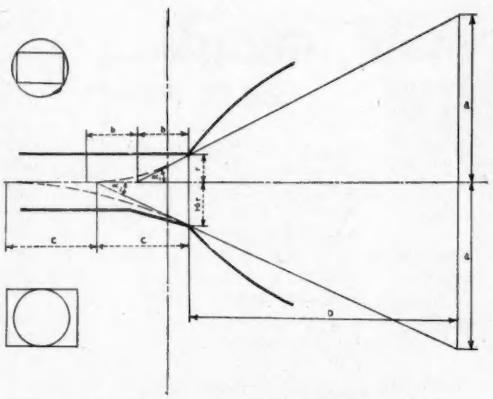


Fig. 10. Modification to shape of tube neck with trapezoidal coils.

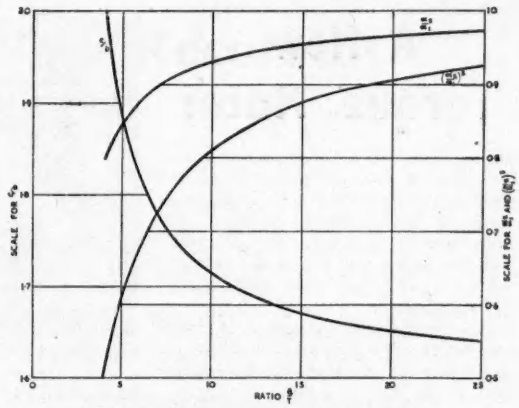


Fig. 11. Relation between factors shown in Fig. 10.

rectangular end, such that the dimension in the frame direction is equal to the internal diameter of the cylindrical part (*see* the lower inset in Fig. 10) and the dimension in the line direction is 5/4 times the frame dimension. This makes the diagonal dimension 1.6 times the internal diameter of the cylindrical part.

The coil length is $2C$, the distance to the screen is D and half the picture diagonal is a. The upper half of the diagram represents the corresponding section of a cylindrical neck of radius r when a picture of the same size is scanned. The upper inset of Fig. 10 indicates by the inscribed rectangle the maximum part of the neck which can be filled. The coil length is $2b$. It can be seen from similar triangles that

$$b(a-r)=Dr \text{ and } c(a-1.6r)=1.6Dr$$

$$\therefore \frac{c}{b} = 1.6\left(\frac{a-r}{a-1.6r}\right)$$

also

$$\frac{\alpha_2}{\alpha_1} \approx \frac{\tan\alpha_2}{\tan\alpha_1} = \frac{1.6r/c}{r/b} = \frac{1.6b}{c} = \frac{a-1.6r}{a-r}$$

Fig. 11 shows plots of $\frac{c}{b}$; $\frac{\alpha_2}{\alpha_1}$ and $\left(\frac{\alpha_2}{\alpha_1}\right)^2$ against $\frac{a}{r}$.

Practical limits for $\frac{a}{r}$ are 4 and 16.

As a numerical example take the MW22-1, a nominal 9-in. tube with a neck 35 mm. outside diameter and 30 mm. inside diameter. The screen diameter is 22.5 cms., hence $a/r=7.5$ and from Fig. 11 we read $c/b = 1.76$; and $(\alpha_2/\alpha_1)^2 = 0.75$. The coil length used with this size of tube and cylindrical neck is 35 mm. Reference to Terman shows that the increase of coil length results in a change of G given by

$$\frac{G_2}{G_1} = \frac{0.0118}{0.0105} = 1.12.$$

An estimate of η may be made from the ratio of the roughly triangular area swept by the beam to the area of cross-section covered by the coil.

For the cylindrical neck

$$\eta_1 = \frac{1}{2} \times \frac{r}{1.28} \times 2c/r \times 2c = \frac{1}{2 \times 1.28} = 0.39.$$

For the shaped neck

$$\eta_2 = \frac{1}{2} \times \frac{5r}{4} \times 2c \Big/ \left(2rc + \frac{rc}{16}\right) = 0.605$$

$$\text{Hence } (\eta_2/\eta_1)^2 = \left(\frac{0.605}{0.39}\right)^2 = 2.4.$$

Referring now to Equation (28) it may be seen that the wattage ratio for the two cases will be:

$$\frac{W_2}{W_1} = \left(\frac{\alpha_2}{\alpha_1}\right)^2 \left(\frac{G_1}{G_2}\right) \left(\frac{\eta_1}{\eta_2}\right)^2$$

$$= 0.75 \times \frac{1}{1.12} \times \frac{1}{2.4} = 0.28.$$

The increase of η will thus account for the major part of the reduction in W due to this alteration of neck shape. Even if a large allowance is made for the various approximations, it seems probable that a reduction of wattage by a factor of 2 to 3 might be made. This proposal has not yet been tested practically, but the results for the trapezoidal coils given above, indicate that the limit to what can be done in this direction will be set by the geometrical distortion of the raster on the screen.

Conclusions

(1) The wattage demanded of the line time base depends partly on the circuit and partly on the C.R. tube and the factors must be taken together in considering a design.

(2) If this overall view is adopted, Equation 28 indicates that time base watts for magnetic deflection are independent of tube neck diameter. If a low voltage and high beam current are decided upon, a large neck diameter will be required, while with a high voltage and low beam current, a small neck diameter should be used, and the time base watts may remain constant.

(3) A comparison of Equation 6 with Equation 28 shows that while for magnetic deflection the wattage increases linearly with $V\sqrt{i}$ (which we have seen is nearly proportional to screen light output), with electrostatic deflection the wattage rises as the square of $V\sqrt{i}$. Hence, even if electrostatic deflection requires less watts than magnetic deflection at low light output, the reverse will be true above some particular value.

(4) If a high screen light output is required, it should be achieved by raising the voltage rather than by raising the current.

(5) Very simple measurements suffice to determine the figure of merit for deflection coils.

(6) It is suggested that a marked gain might result from shaping the end of the magnetic tube neck in a manner analogous to the divergence of deflector plates in electrostatic tubes.

A New Torque Motor

By
A. E. Adams
and D. Waloff*

ORTHODOX torque motors used for servo application have the inherent undesirable features of lack of instantaneous starting and considerable overrun, both of which are due to the inertia of the rotating mass, together with the employment of anti-friction bearings. To overcome these disadvantages it is therefore necessary to depart from standard principles of electro-magnetic operation.

In the torque motor developed by Scophony, Ltd., the orthodox principle of rotating a driving member such as an armature or rotor in anti-friction bearings is replaced by a gyratory motion of a low inertia armature. The gyratory motion of the armature is translated to rotation in the output shaft by a single stage of planetary gearing which is self-locking when the gyration ceases.

The armature gyration may be achieved in two different ways. In the first case the gyrating member is polarised by use of permanent magnet or D.C. excitation and acted upon by magnetic fields arranged perpendicular to the armature, displaced 90° to one another, and supplied with a two-phase alternating source. In the second case two constant magnetic fields can be arranged relatively perpendicular and the armature polarised alternately by phase split currents. In each set-up the gyration is enforced synchronously with the alternating source. Over-run at the instant that the alternating source ceases is prevented by the gyrator pulling over to its nearest sympathetic pole.

Comparatively high torque for small electrical input is obtained by making the single stage planetary gearing give a high reduction ratio with a consequent low output speed.

Referring to Fig. 1 it has been found a practical expedient to have the ferrous gyrator (1) fixed to a diaphragm (2) so that the diaphragm flexibility permits gyration at the end of the armature, but prohibits rotation of the armature with respect to the diaphragm.

The diaphragm (2) is clamped at its periphery between two identical ferrous shells (3), each of which contains a two-pole laminated stator (4)

assembled with magnetic axes in parallel planes but displaced 90° one with the other. Coils (5) and (6) around the stator packs are fed with phase displaced currents which successively attract and repel the permanently polarised armature and cause it to describe a conical motion about the centre of the diaphragm. Since the gyrator moves synchronously with the applied phase displaced currents the output rotating shaft speed is exactly proportional to the applied frequency. The direction of gyration is readily controlled by switching the phase split currents in the exciting coils (5) and (6). Translating gyration to rotation is carried out by using gearing which consists of one gear (7) rigidly mounted on the end of the gyrator and acting inside an internally cut gear (8) which is pinned to the output shaft and rotates with it. Thus if gear (7) has 99 teeth, and can only gyrate in an orbit which is limited by tooth contact with gear (8), and the internally cut gear (8) has 100 teeth, the overall gear ratio is 100/1, since one gyration of gear (7) enforces one tooth advancement of gear (8).

It is arranged that the amplitude of gyration is very slightly greater than the depth of tooth engagement and with the special tooth-form adopted an arc of contact of 240° is obtained. With so many teeth in engagement the gear is capable of transmitting considerable power for its size, and as the clearance on the disengaged side is made smaller than the working depth of gear tooth the gear is precluded from falling out of step with the gyrator.

The frequency of the supply can vary from 1 to 300 cycles per sec., so that using a 100/1 reduction the output shaft will rotate synchronously from 0.6 r.p.m. to 180 r.p.m. For operation of the motor from single phase supply of constant frequency, one phase must be excited directly while the second phase is fed through the necessary condenser to cause the current to lead by approximately 90° electrically, thus producing a rotating field.

It can readily be seen that a system of this kind has great possibilities in the field of remote control, integrating devices, etc., because the starting and stopping characteristics of a gyrator which has a very low mass can be made very uniform indeed. Therefore any number of these actuators fed from the same alternating source must move in unison. Unlike orthodox follower systems which have negligible torque in positions of near balance, the Scophony torque motor operates at full power up to the instant of de-energising and modern means of electronic switching give to this instrument a very high degree of accurate control.

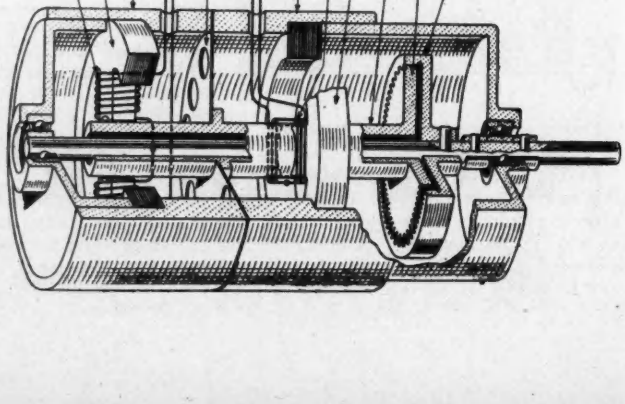


Fig. 1. Sectional View of Motor.

* Scophony, Ltd., Somerset.

16-mm. Sound-on-Film Recorders

By JAMES NEIL, A.R.P.S.,

SINCE the introduction of the first 16-mm. sound film projector, both the commercial user and the advanced amateur movie-maker have dreamed of the day when the introduction of suitable recorders would make their own sound films a practical proposition. Such recorders would require to be simple to use, portable, and not too expensive. Until the war in Europe had begun this desirable state of affairs remained a dream.

It is true that some attempts had been made to supply something of the kind desired, both here and in the U.S.A., but in the majority of cases the resulting recorders were just modified 35-mm. equipments, which retained all the bulk, intricacy, and expense of the larger outfits. Under war conditions 16-mm. direct-recording has received a great deal of encouragement from the requirements of special training and instructional films, and sufficient progress has been made to bring 16-mm. sound-on-film recordings well into the commercial field, as well as to hold a promise of even greater progress in the post-war years. Unfortunately, so far as the writer is concerned, the only really satisfactory equipment available to the commercial user are products of the U.S.A., British sources having shown a marked reluctance to allow their equipments out of their direct control, where they have been developed at all. Therefore, from a practical point of view, the only available equipments are those made in the U.S.

A similar position existed prior to the war, the only successful substandard recorders being those made in the U.S.A., although all of these did not reach this country. Perhaps the best-known of those which reached here was the Bass R.C.A. news-reel camera-recorder, which used the single-system picture and sound recorded on the same film. The normal film load was 100 ft., but extra magazines to permit runs of 400 ft. were also available as a standard extra.

The results available from this outfit seem to have varied. The equipment demanded a degree of skill for its "best" results beyond that of many of those who had the opportunity to use it, as it is certain that in skilled hands it was capable of giving a reasonably good account of itself considering everything related to the standard of the technique of the period. This equipment is still available and was handled by agents in this country.

Another similar type of substandard camera-recorder, which, so far as the writer is aware, never reached this country at all, was the B-M "Sound Pro," which also used a galvanometer recording mechanism to produce a unilateral variable area type track.

The B-M camera-recorder had a range of electric motors available, including 115 V single-phase and 220 V 3-phase synchronous motors, with a 12 V D.C. motor for location work. As these motors were attached to the camera drive by a special bayonet fitting it was a simple matter to change from one type to the other as or when necessary.

Daylight-loading 200-ft. magazines were the standard equipment, but 400-ft. laboratory-loading magazines were also available.

In 1937 this same firm introduced their first "double-system" recorder, *i.e.*, separate films were used for sound and picture takes. This recorder used the same basic equipment as the "Sound-Pro," but the picture and sound mechanism was separated mechanically, an electrical interlock system being used to maintain synchronism between the picture and the sound films. This equipment will be described more fully in its latest form.

Another equipment, of which the present writer has very little information, is the De Vry variable area recorder, which seems also to have been based on the single system. This equipment had a choice of two motors, either 110 V synchronous, or 12 V D.C.: a 400-ft. magazine seems to have been the standard equipment.

In 1940 the announcement of the Auricon seemed to be just the thing wanted by the so many for so long. This equipment, in its latest form, will also be described fully later.

It should be noted that all these recorders used the galvanometer to produce a variable area track; that, with the exception of the later B-M "double-system," all used a unilateral track—the newer B-M Double systems use a bilateral track; both the Auricon and the B-M recorders provide for "noiseless recordings" and "volume compression" automatically.

There would seem little doubt that the galvanometer method of recording has been chosen on all these equipments because its robustness enabled it to be adjusted, and to stay in adjustment despite any rough handling that it was certain to get either by handling or over-loading when in use.

While a number of sound-on-disk systems have been developed for 16-mm. films, these are of little interest to the practical user, for the same reasons that drove the sound-on-disk from the professional cinema; they are not therefore considered by the writer to have any future for sound film work, and no further reference to them need be made.

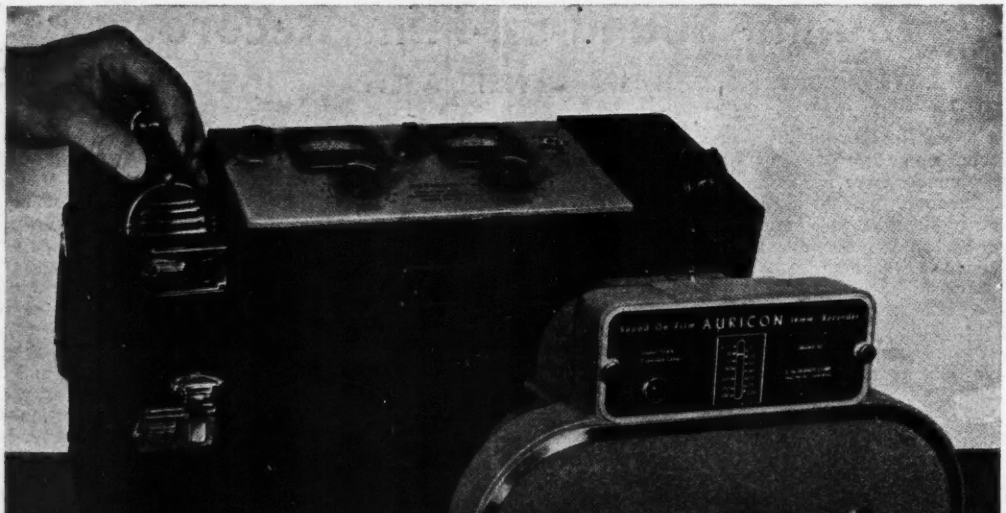
At the time of writing (September, 1945) the following is the position on 16-mm. recorders, so far as the writer's information serves:

No new developments regarding the Bass R.C.A. or the De Vry outfits are known. The B-M "Sound Pro" has been discontinued in favour of the B-M "Double-System"—the latter and the Auricon are both being "brought up to date" before being released on general sale again.

The following descriptions of the latest models of the Auricon and B-M recorders may be of service to others who are considering the use of such equipments for industrial purposes.

Auricon

Constructed to approach the standard of a good 16-mm. camera in cost, ease of use, and results, the Auricon can be used with any good cine camera that can be driven by an electric motor, or adapted to be driven electrically—those that have a hand crank shaft; this includes the Kodak Cine Special, the Bell & Howell series 70 Filmos, the Victor, the De Vry, and the Bolex cameras. The camera and recorder are both driven by synchronous motors, and as these cannot be synchronised at "stand-still" the professional "clapsticks" should be used to mark the beginning of a "take."



Auricon amplifier and recording unit. The chamber takes 200 ft. of film and the whole equipment weighs only 41 lbs. *E. M. Berndt Corp., Hollywood.*

The Auricon is portable and compact, fitting into two light cases "comparable in size to any standard 16-mm. camera carrying cases." The total weight is 41 lb.

One case contains the amplifier, microphone, its stand and cables, and the batteries which supply it with power. The recorder proper is in the other case.

Film loading is in standard 200-ft. spools, and the connecting wiring cannot be wrongly connected. An interlocking arrangement cuts off the battery supply when the cables are withdrawn to prevent accidental discharge of the batteries by leaving the amplifier on while not in use.

All the controls have been simplified to a point where a reasonably intelligent person could soon master their use, although there is more than just the proper use of controls in sound recording as an "art." Music, narration, dialogue, and sound effects can be pre-scored, post-recorded, or directly recorded as desired.

Recorder Unit

The heart of the recorder unit is the recording galvanometer, which has been designed to withstand considerable overloads. The unit is housed in a dual-service carrying case, which also serves as a "blimp;" all connexions and controls may be made and used while the recording unit is in the blimp.

A master switch, which controls both camera and recorder motors, is mounted on the top panel, together with two meters, one of which acts as a volume indicator; the other, in addition to testing the batteries, can, at the flick of a switch, control the sound tract exposure. The film footage indicator and a pilot lamp, which indicates when the recorder lamp is lit, are visible through a glass-panelled window in the side of the case. The estimated life of the recorder lamp is 100,000 ft. (about 45 hours actual recording).

The Amplifier (RA20).

The batteries used are identical with those on midget radio sets. These feed low-drain valves (similar to those used on similar types of midget radios). Both batteries and valves can therefore be purchased anywhere where midget sets are used.

Two input connexions with separate mixing controls permit the outputs of two microphones, two pick-ups, or two film phonographs to be mixed into a single record, or alternatively any combination of any two may be used. Both aural (by headphones) and visual (volume indicator meter) monitoring is provided, the volume indicator meter being used to maintain a constant recording level. The sound track exposure meter indicates the normal exposure for the three most used sound recording films (U.S.A. film stock).

Microphone

This is of the dynamic type. It is provided with a collapsible stand and 50 ft. of microphone cable.

Extras

When a suitable mains supply is not available to drive the synchronous motors a special "power pack," which is contained in "a leather-covered case similar in size to a portable typewriter," is available. This will drive both motors for three hours on one charge (over 6,000 ft. of film).

Good Recordings

Sufficient care has been taken in the construction of the recorder to make certain that the film passes through the sound gate, etc., without any tendency to "wow" or "flutter," and practical tests with the equipment bear out the maker's claims in this respect. A satisfactory tonal quality and volume range is obtained. All the advantages of the "double

system," which permits both films to receive the most favourable exposure and development procedures, together with a much wider choice of film stocks suitable for the different requirements of picture and sound, may be obtained without restricting the quality of either.

The camera and recorder can be used separately as may be found convenient, and once the technique of microphone placement has been mastered the equipment will be found to give an ease of handling beyond the expectation of those to whom it is unknown.

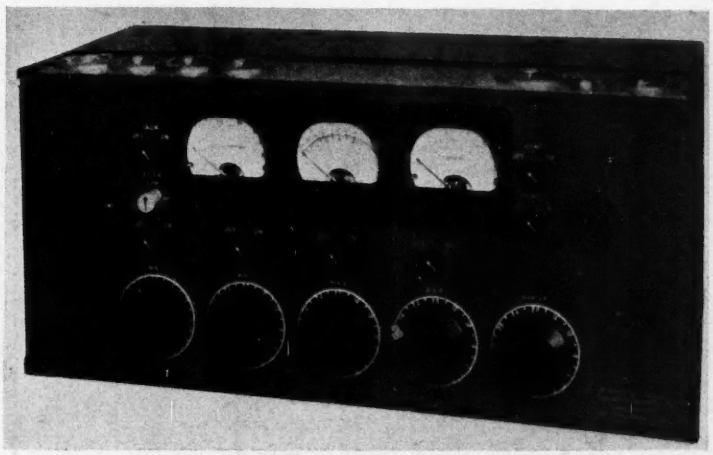
B-M Recorder

With quite different qualities in many respects the B-M recorder has been designed for 16-mm. professional use, and although any good type of camera suitable for an electrical drive may be used, the B-M camera is the natural choice with the equipment. It retains many of the desirable features of the Auricon, but is more elaborate, more bulky, and *ten* times as expensive. This latter factor will limit its selection to those who have serious intentions to use the equipment, and can back their intentions with the necessary cash. Probably for this reason the B-M offers many of the features of a good standard recorder within a small bulk that can be carried in a medium-sized car.

Threading the recorder can be completed in 30 sec. when the operator has practised a reasonable number of times. All electrical connexions are made by fool-proof cannon plugs. The pre-focused recorder lamp can be changed quickly and surely should it fail at an awkward time. Both the recording oscillograph and its associated optical system are locked in adjustment so that even rough handling will not cause them to alter their setting. This optical setting gives the sharpest optical pencil of light ever provided on any commercial recorder (0.00015 in.), resulting in a really good high-frequency response. Records of a combined playing of a violin and piano—the most exacting test for "wow" and "flutter"—prove how satisfactory the recorder is in this respect.

The galvanometer has been tuned for 12,000 cycles, which leaves an adequate reserve when the present cycles are extended.

Six controls are provided. One adjusts the recording lamp current to a suitable value for the film used,



Maurer type 162-B recording amplifier

another maintains the volume at a suitable level; the rest of the controls are for mixing the inputs of the four position mixer.

A special feature of this recorder is the ability to switch over from "negative" to "direct positive" recordings by switching over a single control placed quite conveniently to the hand.

Recording Amplifier (BM-162-B)

This combines the following functions: a single-stage microphone amplifier; a four-position mixer; and a main audio-frequency amplifier; filters and equalising networks; a control amplifier for "noiseless recordings;" a control amplifier for volume compression.

The input of the microphone amplifier has an impedance of 30 to 50 ohms. One 6P5G valve is used. The mixer is permanently connected so that the signal from the No. 1 position can be obtained from the microphone pre-amplifier. The other three positions have an input impedance of 200 ohms, and are thus suitable for connexion to high-quality gramophone pick-ups, the film phonographs, or the output of the B-M model 126A pre-amplifier.

Mixer controls are of the ladder type, having a 2 db. of attenuation per step, with maximum attenuation of 40 db. before reaching complete cut-off on the last step.

The input of the main amplifier is permanently connected to the output of the mixer. The following valves are used in the main amplifier: 1 6F5GT, 1 6J5GT, 2 6K7G, 1 6SN7GT. The amplifier gain, including insertion losses of the associated networks, is sufficient to give an overall gain between the input of the pre-amplifier and the output of the complete amplifier of 110 db., that of the main amplifier shall be in excess of 60 db.

The basic frequency characteristic of the main amplifier is designed to be flat within one decibel from 100 cycles to 15,000 cycles, and not to exceed 3 db. down at 50 cycles—the noise level being held low enough to be inaudible on the recorded film. The total harmonic distortion is restricted to 1 per cent. at the maximum recording level. The amplifier output impedance is 50 ohms.

Filters And Equalisers

The following filters and equalisers are provided:

(a) 80 to 6,500 cycle bandpass filter.

(b) A low-frequency attenuator, with a choice of three conditions, viz.,

(1) Flat response to 100 cycles;
(2) Down 5 db. at 100 cycles;
(3) Down 10 db. at 100 cycles.

(c) Increased high-frequency response to compensate for film loss; two characteristics being given:

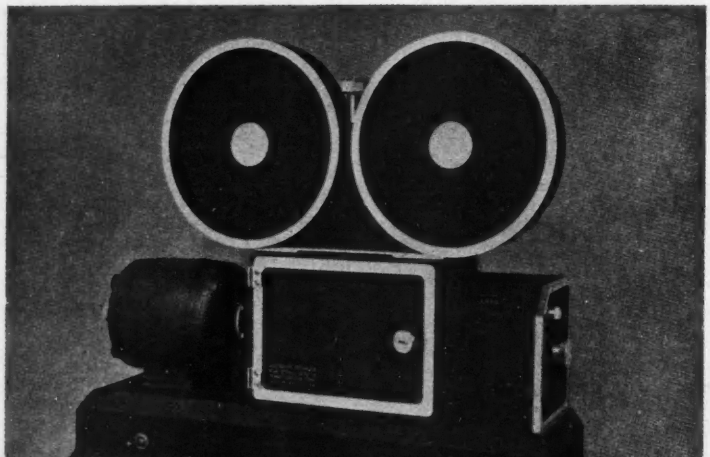
(1) Response up 6 db. at 6,000 cycles.
(2) Response up 12 db. at 6,000 cycles.

Noiseless Recording Control Amplifier

Four valves as follows are used: 1 6SN7GT, 1 6X5GT, 2 6V6GT. The amplifier provides a maximum bias current of 35 mA., which is controllable by means of an adjustable rheostat, and a milliammeter reading up to 50 mA.

Volume Compression Control Amplifier

This uses one 6SN7GT and one 6X5GT valve. The compressor action begins when the input reaches



B.M. sound recorder with recording light beam of .00015". *Berndt-Maurer Corp., N.Y.*

a level of 10 db. below the full modulation of the recorder with which it is designed to be used. A switch is provided to render the compressor inoperative. The compressor action is outside audible-frequency limits.

Main Gain Control

Covering a range of 40 db., in steps of 1 db. each, the main gain control adjusts the levels of the audio-frequency signals supplied to the recorder.

Construction

Built on a solid two-deck construction, the amplifier is housed in a 1/16-in. sheet-steel case measuring 18 in. by 8 in. by 8 in., which is in turn fitted into the fibre carrying case. The top of the case is removable to permit the operation of the amplifier without removing it from the fibre protecting case. The two-deck construction can be separated easily, as all the connecting wires (11) are brought out to terminals where they are interlinked by means of screws and terminal lugs. This permits easy servicing of the complete amplifier. The finish is in slate-grey wrinkle enamel-backed. All the interconnexions between the units are made by shielded rubber cables with cannon plugs; all of these cables enter and leave the equipment on the far off-side from the operator's position.

B-M Camera

This has been specially designed for working with this recording equipment, but it can be used separately just as well. Any other camera suitable for synchronised running can be used, however, equally well. The camera shows the same careful construction as the amplifier and recorder. Complete with motor and magazine, the camera weighs 26 lb., but is easy to use despite the weight and the 400-ft. magazines, which are standard and can be used on both camera and the recorder. Special 1,200-ft. magazines are available to special order. Synchronous motors of 1/50th H.P. in both single phase 115 V and 3-phase 220 V are available for mains operation and a 12 V D.C. motor of 1/30th H.P. is also available.

The film take-up can be driven backwards and forwards by the positive gear drive, the actual film being driven by a 14-tooth combination feed and hold-back sprocket, and a cam-driven claw-type intermittent mechanism in a straight picture gate.

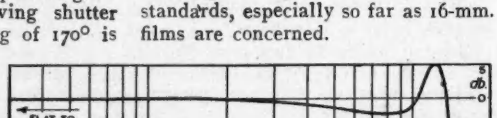
A double-blade dissolving shutter with a maximum opening of 170° is supplied as standard, the opening being varied by a manual control, the full aperture exposure being 1/50th sec. As an alternative a fixed shutter with a 240° aperture is available giving an exposure of 1/35th sec., half a stop greater than the 170° shutter.

Lenses are mounted in a three-lens turret using the "C" type mount, fine focusing being done by a viewing microscope, thus ensuring sharp focus. A large erecting prism type viewfinder gives automatic adjustment against parallax.

Constructed in cast aluminium and duralumin, which has been anodised, then finished in slate-grey wrinkle enamel, the equipment has a fine appearance in addition to its good workmanship. With over eight years practical experience of this camera in actual use behind the present models it is certain that there is nothing experimental about the complete equipment, for which the makers claim, with some justification, that they are the leaders in this field.

Conclusion

It is hoped that this brief summary of the recognised 16-mm. recording equipments that have been available will be of some assistance to those who are interested in the development of 16-mm. sound equipments. Unfortunately, with the exception of the three major companies (R.C.A., Western Electric, and British Acoustic) no British-made equipment has attained any degree of commercial success, especially if they be judged by the standards of the films that have been released from those handling the equipments. While those of us who are interested in the production of commercial films in substandard sizes would welcome the appearance of a good British equipment comparable with the two American equipments so fully described above, there is no sign of its appearance. This is perhaps all the more strange when we consider that the British disk recordings are superior to those of the American disk recordings; yet our sound recording on films generally falls below their standards, especially so far as 16-mm. films are concerned.



Galvanometer Characteristic —*J. A. Maurer, Inc.*

Metal Rectifier Developments—

Possible Applications of Titanium Dioxide.

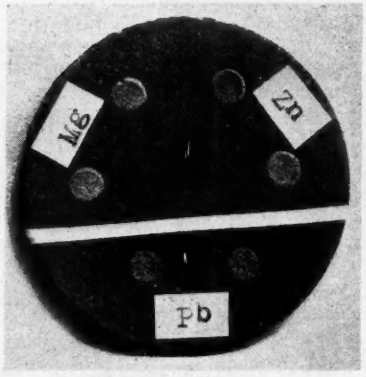
By H. K. Henisch, B.Sc., A.Inst.P.*

As in the case of most radio components, metal rectifiers are receiving a good deal of attention with a view to improving their performance, reducing their size and weight, and increasing their life. A number of new materials have appeared during the last few years which have revolutionised many aspects of component design. The conducting modifications of titanium dioxide have not so far received a great deal of attention, but their great potential uses are beginning to be appreciated.

The types of metal rectifiers at present in use, while in many respects satisfactory, could be improved upon in several ways. In particular it would be desirable to have rectifiers which can operate at high temperatures (*e.g.*, 100° C.) without great loss of efficiency and with a satisfactory working life. A further limitation of the familiar types is the low reverse voltage which can be applied. Considerable applications could be found for new high-voltage and low-current rectifiers of small size.

Several methods can be explored with a view to achieving the desired developments. For instance, low-current types of germanium rectifiers have already been made and successfully applied.[1] These units are rated up to 30 mA D.C., and inverse voltages of 100 V have been quoted. As far as is known these rectifiers are capable of operating at temperatures up to 100° C. The development of corresponding high-current types would be very desirable, as would be an investigation into the merits of tellurium as a rectifying medium.

Research is also in progress on rendering selenium rectifiers capable of withstanding high reverse voltages. There are at least three ways in which this can be done. Firstly, special care can be taken to ensure that the thickness of the selenium layer is uniform. This prevents excessive local currents which cause breakdown. Secondly, a very high reverse resistance—and hence a high reverse voltage rating—can be produced by suitable control of the forming process. In particular a slow forming process while the disks are maintained cool favours a high reverse resistance. Thirdly, it is possible to interpose a thin layer of varnish between the selenium and the counter-electrode. If the materials are suitably chosen, this process will achieve a high reverse resistance without at the same time increasing the forward resistance unduly. Such rectifiers have been known for a number of years,[2] but have not found general application. Recently they have re-appeared as high-voltage rectifiers, especially in the United States. This line of development may have its disadvantages, but it is by no means exhausted. It may even be possible to produce a rectifier with a thin film of glass (or quartz) as a "barrier layer." However, while the complete solution of these problems is not in sight, it is desirable to explore alternative lines of approach, and the application of titanium dioxide deserves consideration in this respect.



Experimental disk of blue TiO_2 with various electrodes. The lead electrodes are sprayed on to a very thin film of polythene which covers the lower part of the disk.

Structure of Rectifiers

It is not intended to go into details of the many theories which have been suggested as explanations of the complicated electrical phenomena occuring in a dry plate rectifier. For present purposes it is sufficient to draw attention to the fact that every rectifier consists of a semi-conducting layer to which two metal contacts are attached. The contacts must be such that when a current flows through the combination, most of the voltage must be across one of them. Rectification takes place at this "bad" contact, the resistance of the second contact being always low.

The rectifying efficiency of such a combination depends on several factors, *e.g.*, the difference in the thermionic work functions of the metal and the semi-conductor, the presence of "artificial" barrier layers and also the physical differences in the structure of the two metal contacts. It should be noted that the semi-conducting material itself need not, and in general does not, exhibit any non-linear conduction, as can easily be confirmed by potential-probe measurements.

In the past, rectifier production has always started with a metal plate (*e.g.*, copper, steel, aluminium, magnesium), onto which a semi-conducting layer was then grafted (*e.g.*, by heating or application of selenium or of pressed cupric sulphide disks). This is then followed by suitable chemical and heat treatments and finally by the application of a counter electrode (*e.g.*, graphite, lead, various low melting-point tin alloys). Theoretically it is possible to start with a slab of semi-conductor and to proceed by applying to it two dissimilar electrodes.

Physical Requirements

For practical purposes it is not sufficient that a combination as described above should exhibit a small amount of asymmetry. Not only must the asymmetry be very considerable (*e.g.*, current ratios of the order of 100 : 1 in opposite directions) but a number of other conditions must be

* Royal Aircraft Establishment, Farnborough.

fulfilled. The most important of these are :—

(a) Conduction must be purely electronic, not ionic. Ionic conduction (even if it is only responsible for a fraction of the total current) leads inevitably to chemical and structural changes, resulting in instability and short life. The cupric sulphide rectifier is a good example. Conduction in this case is partly ionic and results in the growth of copper nodules which eventually short-circuit the two electrodes.

(b) The materials must be inherently stable and not subject to ageing phenomena.

(c) The semi-conductor should preferably have a low specific resistivity and at the same time a thermionic work function which differs very greatly from that of the counter-electrode.

(d) The material must not change appreciably during prolonged exposure at any temperature between (say) − 50° C. to + 130° C.

(e) The raw materials should be easily obtainable and of low cost.

(f) The properties of the materials should be capable of being accurately controlled during the process of manufacture.

(g) It should be possible to protect the material from the influence of moisture and atmospheric pollutions, or, for purposes of high-voltage operation and cooling, to immerse it in oil.

These are the conditions which must be satisfied before any departure from existing types could result in a significant improvement. The number of semi-conducting materials which are applicable is not very large. Titanium dioxide, rendered conducting by suitable treatment, is thought to offer promising possibilities, although it is recognised that there may be other materials of similar merit.

Blue Titanium Dioxide, Manufacture and Properties

The normal form of titanium dioxide is a white crystalline powder. The material is in plentiful supply (in adequate purity) and is sometimes used commercially as a pigment. Electrically it is an excellent insulator when in a pure state, and as such and because of the high dielectric constant (approximately 96) it is used in the manufacture of ceramic capacitors. In the course of this manufacture it sometimes occurs that the material acquires a blue colour and is rendered conducting, thus becoming useless as a dielectric.

For some years attempts have been made (notably by Osram in Germany, but also by some firms in this country) to investigate the causes of this phenomenon, to determine the various properties of the blue substances and to suggest suitable applications.

If the material is produced deliberately (as opposed to accidentally during the manufacture of capacitors) the procedure is as follows :—

The powder is mixed with a binding agent (starch or various proprietory binders) and varying proportions of magnesium oxide, until it forms a stiff paste. It is then extruded or otherwise shaped into any desired form and fired at a temperature of about 1,050° C. This burns off the binder and leaves the material still white and non-conducting. The material is then fired in a reducing atmosphere (usually hydrogen) at temperatures between 1,500 and 1,700° C. for several hours. During this process the material is rendered conducting and its colour changes to varying shades of blue, from light blue to almost black. The exact nature of the change is not yet clearly understood. During the process minute traces of TiO_2 are thought to be reduced to Ti. These would represent flaws in the (cubic) crystal structure of the mixture, which could furnish free electrons and thus make conduction possible..

Between the first and second firing process it is possible to dip the material into a molybdenum paste and thus provide it with an electrode. The adherence of the molybdenum after firing is very firm, but purely mechanical.

The final properties of the product depend on a number of parameters, *e.g.*, amounts of binder and magnesium oxide used, firing temperatures and durations, pressure of reducing atmosphere, etc. The specific conductivity and temperature coefficient of the material are found to be related, as expected from the theories of semi-conductors. The thermal conductivity of the electrodes can also have a marked influence in certain cases. To a considerable extent the properties can be controlled by suitable choice of the manufacturing parameters. (The purpose of the magnesium oxide is to slow down the reducing process and thus to facilitate control during manufacture. Mixed crystals are formed, consisting partly of TiO_2 and partly of MgO.)

The material as such has numerous potential applications. Some of its properties, particularly its behaviour at elevated temperatures, are described by Meyer[3], and the fact that conduction through the material is purely electronic has been shown by Earle[4].

Titanium Dioxide Rectifiers

It is clear that in order to produce titanium dioxide rectifiers three main problems will have to be solved.

Firstly, it must be possible to produce the conducting material consistently and with the desired properties of high stability. This should not represent any great difficulty, since the processes involved are by now quite well established.

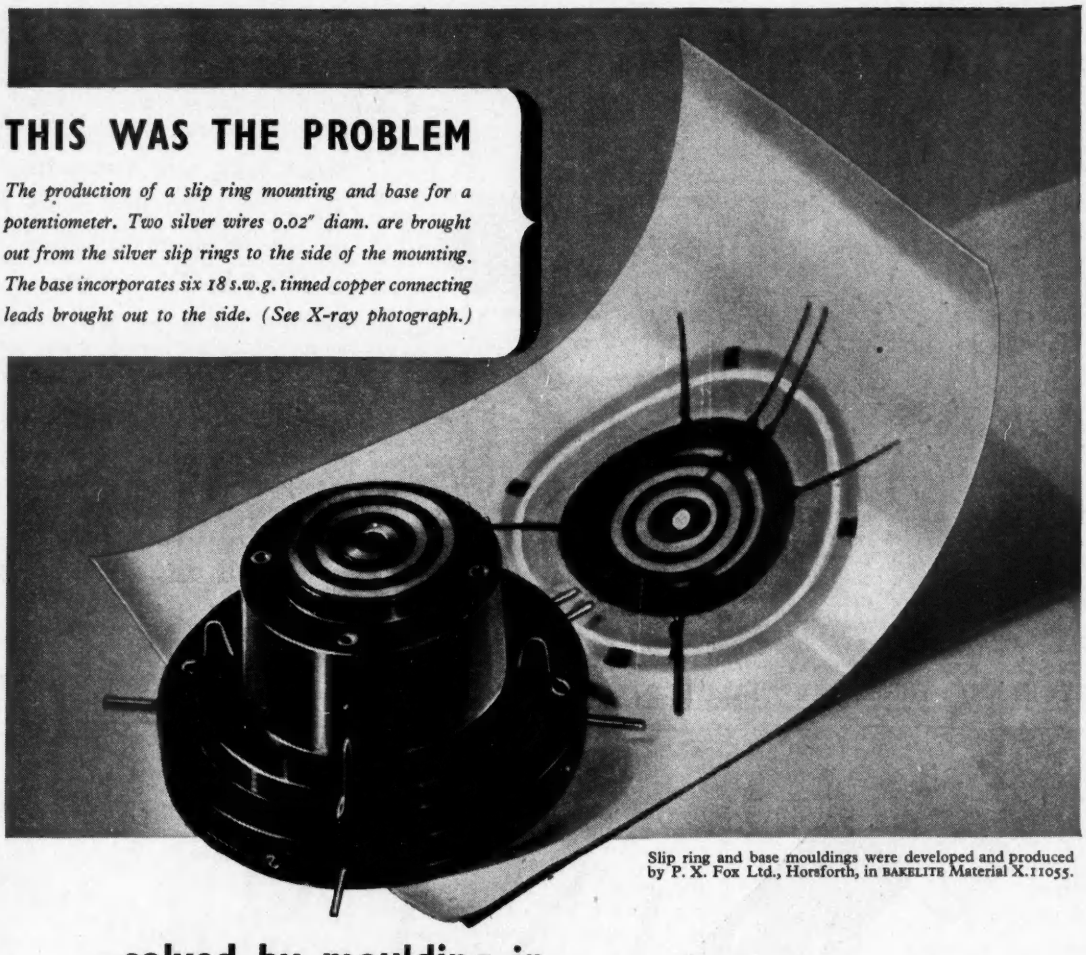
Secondly, the semi-conductor must be produced in the form of thin films. Limited experiments on titanium dioxide rectifiers carried out in the past have not been successful because the production of thin films had not been mastered. Even then, however, current ratios of 6 : 1 have been achieved with disks of 3 mm. thickness, and while this is still far from satisfactory, it is evident that a reduction of plate thickness would greatly increase the current ratio by eliminating a resistance which is common to both directions of current flow. In the meantime a great deal of work on the production of thin films has been carried out, particularly by Osram in Germany. Films as thin as 5-10μ have been produced by allowing a thin paste of the material to spread on a glass surface.

Thirdly, experimental work is required to determine the most advantageous electrode materials and modes of application. Since the semi-conducting films are very fragile, the electrodes must also offer mechanical support. Various possibilities can be envisaged.

Since the material is conducting the

THIS WAS THE PROBLEM

The production of a slip ring mounting and base for a potentiometer. Two silver wires 0.02" diam. are brought out from the silver slip rings to the side of the mounting. The base incorporates six 18 s.w.g. tinned copper connecting leads brought out to the side. (See X-ray photograph.)



Slip ring and base mouldings were developed and produced by P. X. Fox Ltd., Horsforth, in BAKELITE Material X.11055.

—solved by moulding in

BAKELITE MATERIAL

Here is a job that is obviously one for plastics. To build up the potentiometer from machined components would not only be an extremely difficult task but the result would not be comparable with that obtained by the use of BAKELITE Plastics.
Plastics should be used only on the right jobs, but even more important is the choice of the right plastics.

TREFOIL

BAKELITE PLASTICS

REGD. TRADE MARKS

Pioneers in the Plastics World

BAKELITE LIMITED · 18 GROSVENOR GARDENS · LONDON S.W.1

T.64

WHAT THE ?

It's really quite simple . . . Dumb-bells and Armchairs are just the descriptive names for two of the many shapes of MYCALEX Mouldings now produced.

- High Dielectric Strength
- Mechanically Stable
- Close Tolerances
- Heat Resisting
- Non-absorptive
- Metal Inserts
- Non-tracking
- Low Loss
- Resistant to Fungus Growth

'Phone : Cirencester 400 or send enquiries to

MYCALEX COMPANY LIMITED, ASHCROFT ROAD, CIRENCESTER, GLOS.

MY13

PAINTON
VITREOUS RESISTORS

Painton Vitreous Resistors are available in values from 1 ohm to 100,000 ohms; from 10 watts to 150 watts rating, and are made in a wide variety of fittings.
The Resistors consist of a fully vitrified porcelain tube, which carries a winding of high-grade resistance alloy wire. The ends are electrically welded to the copper terminal leads. This winding is held firmly in position by a coating of extremely durable vitreous enamel, rendering the unit absolutely impervious to the effects of moisture, and ensuring absolute stability of value under all conditions of service.
Type approval of these Resistors has been given for use under the most severe tropical conditions.

PAINTON & CO. LTD

KINGSTHORPE NORTHAMPTON

disks can be directly plated (*e.g.*, with copper or silver). Alternative electrodes are molybdenum, aquadag, lead foil, chemical silver or platinum deposits, embedded metal grids, and metals deposited by sputtering or vacuum evaporation.

It is not possible to forecast which of the various combinations will be the greatest success, although it is possible to say in advance that all pressure sensitive combinations are undesirable. So far the greatest degree of asymmetry has been achieved with copper plating on one side and a chemical silver deposit on the other, the copper being the "good" contact.

Lastly, as in present rectifiers, the possibility of producing artificial barrier layers must be considered. There are, in general, two main methods of achieving this; firstly, by interposing a thin film of insulating material between the semi-conductor and one of the metal contacts, and secondly, by means of an electrical "forming" process, involving dry electrolysis. Whether such a forming process is actually possible in the case of TiO_2 remains to be ascertained.

Conclusions

The above account should not be taken to mean that the titanium dioxide rectifier is on the threshold of commercial application. Experimental work is still required and a number of technological problems will have to be solved. It may be that unexpected difficulties will appear at a later stage of the development. At the same time a consideration of the various factors involved and reference to results previously obtained show that the titanium dioxide rectifier represents a very promising method of approach, which could probably be exploited to great advantage in parallel with rectifier development proceeding on more traditional lines.

Acknowledgment

The author wishes to thank the Ministry of Supply for permission to publish these notes, and Messrs. Steatite & Porcelain Products, Ltd., for kindly supplying experimental materials.

References

[1] *Electronic Engineering*, 1946, Vol. XVIII, No. 216.
[2] HARTMANN, *Phys. Zeitschrift*, 1936, Vol. 37, p. 862.
[3] W. MEYER, *Phys. Z.*, 1935, Vol. 36, p. 749.
[4] M. D. EARLE, *Phys. Review*, 1942, Vol. 61, p. 56.

Long-Distance Television

A NUMBER of claims for the reception of television signals at considerably greater distances than the stated 40-50 miles service area of the B.B.C. London television station at Alexandra Palace have been made from time to time, including reception at Minehead, in Somerset, and a freak reception in America.

From the personal knowledge of the writer, another claim for long-distance reception must now be recorded. On Monday, June 17, 1946, in Torquay, South Devon, about 200 miles from the transmitter, satisfactory reception of both video and audio signals was obtained. The equipment used was one of the new Pye post-war B 16 T table model receivers, to be marketed in the autumn at £35, plus £7 17s. 3d. P.T., brought home on his holiday by Mr. Derek Swaine, a research technician at Pye, Ltd., of Cambridge.

Using the standard Pye aerial, comprising two inductively loaded continuous rods tapped at high impedance points by support arms, terminating in the primary of a transformer for matching the 80-ohm downlead which passes through steel pole cut to act as stub section, temporarily attached to a chimney, these 8 in. by 6 in. pictures on a black-and-white tube were obtained.

While admittedly freak reception at such a distance, it must be classified as a regular freak, because since June 17, the morning, afternoon and evening transmissions have been received at this particular location in Torquay, a cliff-top villa with an unobstructed view over Babbacombe Bay.

The programme technical quality is not 100 per cent. entertainment value, as the picture and sound are affected by slow fades, up to few minutes' duration, and strong interference, *e.g.*, vacuum cleaners, blots out the picture, but all programmes can be followed without real difficulty. It is interesting to note that the picture and sound signals fade alternately.

Presumably reception must be attributed to a combination of factors, such as refraction effects, height of aerial, particular location, increased power of the transmitter, and efficiency of the new receiver.

D. W. ALDOUS

TELEVISION COMMENTARY

"WINGATE of Palestine, Ethiopia and Burma" (August 30) must have convinced doubters that television is really worth while. The unadorned narratives of General Wingate's companions, presented with sincerity and restraint, put this studio production in a different category from any other yet attempted since the war. It earned appreciation on all sides and was the high-water mark of the past four weeks.

At the other end of the scale was a play specially written for television, "The Traveller Returns" (September 13), which at one point introduced a negative image to convey an experiment with time for which the script was inadequate. This was a gruesome little play of the blitz. "Suspect" (August 13 and 21), which was well and realistically produced without camera tricks, also struck the doubtful note of gruesomeness. Doubtful, because television is entertainment in the home where horror is an intrusion unless handled with reserve.

The magnificent pictures of the Victory Parade set the Outside Broadcast section a standard which is hard to follow. This applies particularly to artificially illuminated indoor scenes such as the Hammersmith Palais de Danse and the Wembley Ice Skating which are, perhaps, beyond the present technical resources. Is it possible that programme builders and producers, in their enthusiasm for experimenting with subjects which *they* see in actuality, are not sufficiently critical of the picture the viewer sees at home? It is surely important, if only from the publicity angle, that, by now, the picture should be intelligible to the viewer or should not be shown.

That important and popular weekly feature, "Picture Page," is still searching for the pre-war style of the Leslie Mitchell-Joan Miller team. It is brighter since Wynford Vaughan Thomas intervened, but the perfect hostess for the Thursday guests at Alexander Palace is late in arriving.

Joyce Grenfell's voice has teased us so successfully by radio, that it is with regret we have been forced to realise by television that she is a charming artiste and not the amusing offender of a hundred "gaucheries."

JEAN BARTLETT

The Development of Infra-Red Technique in Germany

By V. KŘÍŽEK and DR. V. VAND, F.R.A.S., F.Inst.P.

DURING the war, the Germans made some interesting advances in the infra-red technique with the object of developing a means for the war interception of the military targets and objectives, such as ships, submarines, cars, tanks, factories, trains and aircraft. In this country, radar was developed for similar purposes. Although radar has many advantages, such as a high accuracy in the range-finding, the infra-red interception has an advantage of surprise and secrecy, as the occupants of a target never know if they are intercepted. The camouflage of the targets is also very difficult, as the majority of the military targets are warmer than their surroundings and the accurate equalisation of the temperature of the engines, exhaust gases, etc., with the surroundings is practically impossible.

Germany spent great effort in elaborating infra-red detectors. This was due in part to their failure to produce powerful centimetric radar oscillators. Research was carried out in the Universities and Research Institutes in Göttingen, Berlin, Erlangen, Dresden, Heidelberg, etc., and many industrial concerns, such as AEG, Zeiss-Ikon, Elac, SAF, etc., worked on the practical aspects of the development. German scientists carried out research on semi-conductors, phosphors and related subjects. Research was also carried in the occupied territories, and sufficient amount of material of the research, carried out by the Germans in the closed Czechoslovak Universities, fell in the hands of the Czechs to enable to reconstruct some of the apparatus and processes.

Every object which is warmer than its surroundings emits more infra-red radiation than it receives. The infra-red radiation is well reflected by the metals, so that by parabolic reflectors an image of the object can be formed and viewed by a device sensitive to infra-red. The most sensitive detectors of the radiation seem to be the resistance photocells, where a resistance of a semi-conductor, incorporated in an electrical circuit, changes its value on irradiation by infra-red. Resistance photocells seem to be more sensitive than the thermoelectric elements and piles, used before the war, and their sensitivity can be further increased by interrupting the radiation by a rotating sector and amplifying the resulting A.C. component by a low-frequency amplifier. The Germans, however, developed several electronic devices, which, working with an extended image in infra-red, can transform it into a visible image on a fluorescent screen, representing thus an "infra-red telescope." The barrier-layer, the vacuum and the gas-filled types of photocells seem to be less suitable than the resistance type.

The semi-conductor of the resistance photocell is prepared by introducing atoms of a heavy metal into a crystal lattice of a non-metal. The metallic atoms on irradiation absorb the infra-red radiation and supply thus electrons into the non-occupied zones of the non-metal, where they can move freely and thus conduct an electric current, before being captured by some other metallic atom. As the increasing atomic weight of the metal used shifts its absorption edge further in the infra-red, heavy metals are preferred. So, for example, thallium sulphide with a small excess of thallium can utilise radiation up to 1.3 μ, where a series of bands of water vapour begins to absorb heavily, with the exception of a few narrow transparent regions between 1.5-1.7, 2.0-2.3 and 3.4-4.5 μ. These regions lie in the useful range of a lead sulphide and especially of a lead selenide photocell, the range of which extends to 5 μ. There is not much experience with lead telluride photocell. Above 5 μ, water vapour, ever present in the atmosphere absorbs the radiations rather heavily, so that increasing the sensitivity range over this value is of no further value for the interception purposes.

The resistance photocells are made by evaporation in vacuo of the required compound or of the reaction components. A sensitive layer of only a few mμ thick is deposited, having a

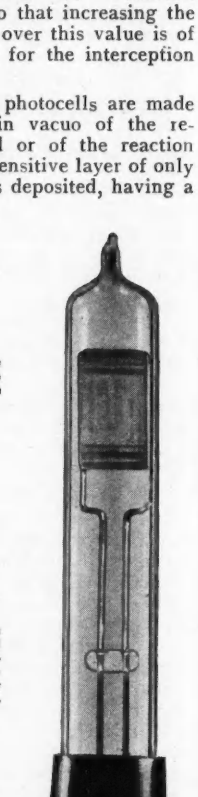
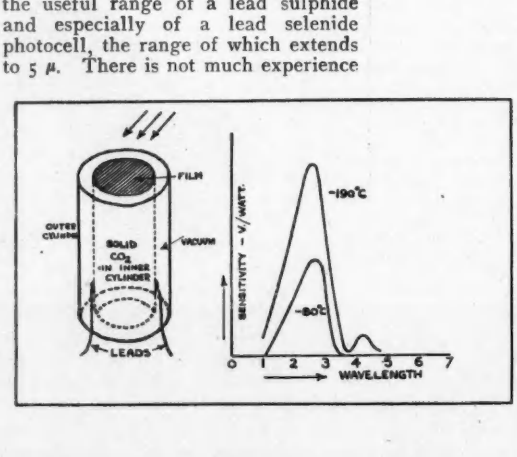


Fig. 1. Thallium sulphide resistance photocell, sensitive to infra-red.

Fig. 2 (below). Sketch of lead sulphide cell in evacuated cylindrical tube and (right) spectral sensitivity curves for lead telluride cell.



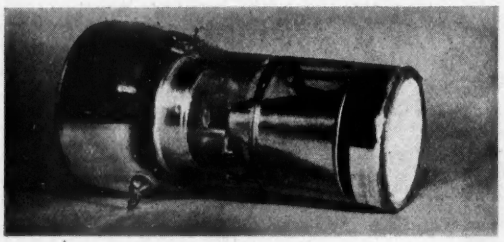


Fig. 3. Infra-red image changer, manufactured by A.E.G.

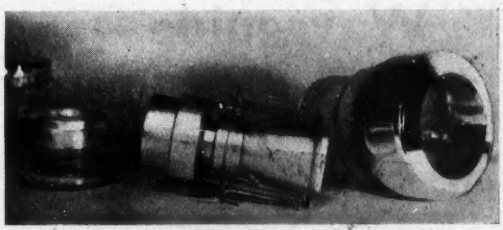


Fig. 4. Electron optical components of an image changer.

resistance of the order of a megohm. An evaporation technique, similar to that used for aluminising astronomical mirrors, is used. High vacuum, however, need not be always used. The layer may be deposited on a clean thin glass surface, provided with suitably placed electrodes. If a chemical reaction of the components is required, the layer may be allowed to " ripen," which may be accelerated by heating in a suitable atmosphere. For example, PbS and PbSe, if pure, are not photosensitive, but by " ripening " in an atmosphere containing oxygen, a certain amount of impurity is introduced in the layer, which makes it photosensitive. The electrodes may be prepared by the evaporation in vacuum of a thicker layer of some well-conducting metal, such as gold or silver, or by application of a coating of a colloidal graphite.

The actual sensitive surface of the photocell may be very small. One typical photocell had the distance between the electrodes only 0.092 mm. and was only 0.3 mm. broad, so that the actual active surface was only 0.027 mm^2. The resistance of this PbS photocell under darkness was 10^8 ohm, and its optimum range of operation, given by the minimum noise to photocurrent ratio extended from 1 to 10 volts, when the radiation was interrupted at a frequency of 250 cycles/sec. and the A.C. component amplified. Below 1 volt, the amplifier noise begins to increase over the photocell noise, whereas above 10 volts the photocell noise begins to increase faster than the photocurrent. When illuminated by $0.84.10^{-6}$ watt/$mm.^2$ (about 30 Lux), (which represents $2.3.10^{-8}$ watt falling on the photocell) when 10 volt was applied, the D.C. component was about 10^{-4}A, whereas the photocurrent was 4.10^{-7}A and the noise level 10^{-8}A. The minimum sensitivity of this photocell is thus about $1.2.10^{-10}$ watt at the room temperature. Thus the advantages of such photocells are small dimensions, low applied voltages, and high sensitivity without the necessity of using cooling baths surrounding the photocell. This makes them suitable to be operated in the focus of a parabolic mirror.

Large surface area photocells were also made (Fig. 1). Zeiss Ikon and Elac manufactured photocells for detection of radiation without the use of parabolic reflectors, having areas of 2-4 $cm.^2$, built in small Dewar vessels and cooled by carbon dioxide freezing mixture, which decreases the background noise. However, the inertia is increased appreciably by cooling, so that the photocell does not respond to rapid changes of the illumination. The electrodes being further apart, the applied voltages are higher, of the order of 40-200 volt. (Fig. 2.)

Extensive experiments were also made with phosphors of ZnS, CdS, CdSe, and CdTe type, which on illumination with the infra-red change their dielectric constant. The phosphors are activated with traces of heavy metals such as 0.1-2 per cent. copper, and are prepared in autoclaves at high temperature and under pressure of some thousand atmospheres. The phosphor is introduced as a variable dielectric between the spaces of two comb-shaped condenser electrodes, which form a part of a tank circuit of a high-frequency oscillator. Beats are produced on mixing the variable frequency with a constant frequency of a second comparison circuit, and their change of pitch indicates the intensity of the illumination. The sensitivity is of the order of 10^{-10} watt.

Another spectacular development consisted of the use of the image changers, or infra-red telescopes (Fig. 3), which were able to convert an infra-red image projected on a photocathode, into a visible image on a fluorescent screen. One type of the image changer uses a transparent photocathode of Cs-AgO or Ag-Cs_2O-Cs, prepared by evaporation in vacuum. The device works on the following principle: An infra-red image is formed by a suitable optics on the photocathode, which emits electrons according to the intensity of the radiation at each point. These electrons are accelerated by an electrostatic field and focused by means of an electron optics (Fig. 4) on a fluorescent screen, where they produce a corresponding visible image. The electron current is of the order of 40 μA/Lumen, and the luminosity of the visible image depends approximately on the square of the accelerating voltage. At 20 kV, a nearly tenfold gain in the energy of the incoming radiation was obtained. Further amplification may be obtained by building two or more image changers in a series. In this case, the intermediate fluorescent screens are made to have a blue-green fluorescence, and are coated at the other side by a material sensitive to blue-green light. The whole " reinforcing foil " may be only 30 μ thick. Coatings of Cs-Sb were used for this purpose, being prepared by alternate evaporation of Cs and Sb layers, which were allowed to diffuse into each other at 110°-130° C.

Another instrument used by the Germans was an infra-red iconoscope. It does not differ in general principle from the iconoscope used in television, the only difference being in the photosensitive layer. Whereas in television, a mosaic layer, emitting photoelectrons is used, the infra-red instrument uses a semi-conducting layer, the resistance of which changes on irradiation. An infra-red image, projected on such a layer causes thus local changes of the resistance according to the intensity of the illumination. When scanned by an electron beam, the current changes according to the local resistance of the spot hit by the beam. After amplification of the A.C.

(*Continued on page* 322)

Waveguide Measurements

By G. ASHDOWN, A. Inst. P.

Fig. 1. 10,000 Megacycle (3 cm.) Waveguide Test Bench.
By courtesy of British insulated Callender's Cables Ltd. and Nash & Thompson Ltd. in collaboration.

THE possibility of transmitting electrical energy through a hollow metal tube has been known for nearly half a century (1), but it is only during the last decade or so that equipment has been available to enable progress to be made in the experimental field.

In the case of open wires, transmission line theory has been of inestimable value to the engineer, and its extension to the coaxial cable, even at relatively high frequencies, has proved sound. But attempts to extend further this theory to include waveguides, or even coaxial cables at ultra-high frequencies, have not always been successful and it is becoming increasingly evident that the ordinary line equations, involving current and voltage, cease to be applicable at these high frequencies. This is partly due to the difficulty of defining current and voltage, but the main cause is the fact that discontinuities are frequently comparable, in size, with the wavelength of the oscillations.

The erroneous results to which the ordinary line equations can lead when applied to transmission lines at ultra-high frequencies were strikingly demonstrated in a recent paper (2) read before the I.E.E. This paper rightly stressed the danger of applying equations which have been established for certain specific conditions without making sure that these conditions still exist. At ultra-high frequencies it is often necessary to unudertake a critical analysis of equations which have been previously accepted without question.

In the early stages of a new development, such as the exploitation of ultra-high frequencies, it is generally possible to obtain reasonably satisfactory results with a minimum of precise theoretical knowledge. But in later stages accurate measurement became essential and it is then that suitable equations must be established and more specialised knowledge be brought to bear on the subject.

In 1939, frequencies in excess of 50 Mc/s. had been used only on a very limited scale and few ultra high frequency measurements were required, but during the war, waveguides carrying frequencies as high as 10,000 Mc/s. came into use for radar equipment and new methods of measurement became necessary. With the possibility of the use of waveguides being extended, it is interesting to note that a waveguide test bench covering the frequency range 9,200 Mc/s. to 9,550 Mc/s (wavelengths between 3.14 cm. and 3.26 cm.) was exhibited by Messrs. B.I.C.C. at the Physical Society Exhibition last January. This test bench, developed in collaboration with Messrs. Nash & Thompson, Ltd., is the result of wartime experience in overcoming the difficulties peculiar to waveguides. The layout is more compact than that of the wartime test benches, as the possible need for semi-portable equipment has been considered. Numerous adaptors are provided, to enable different types of guide to be accommodated, and the accessories have been chosen to meet the requirements of both industrial and tutorial laboratories. The test bench, connected to its power supply unit, is shown ready for operation in Fig. 1. When not in use, the bench is housed in a fitted wooden carrying case, together with the accessories and adaptors required for measurement purposes (Fig. 4). Two pairs of adaptors are provided to enable $\frac{7}{8}$ in. dia. or 1 in. × 11/32 in. rectangular guides to be tested; without adaptors the bench can be used for testing 1 in. × $\frac{1}{2}$ in. guides. In addition, a pair of mode convertors for use with $1\frac{1}{8}$ in. dia. guides is included. The convertors are designed to change the H_{01} mode wave in the bench into an E_{01} mode wave in the circular guide.

The test bench consists of a short length of waveguide carrying successively a Klystron type oscillator, a launching aerial, a 10 db. attenuator, a coaxial line wavemeter and a standing wave detector. The coupling of the standing wave detector and the associated cavities are such that a sufficiently wide band of wavelength is covered to enable a satisfactory output to be obtained over the whole range of the oscillator without tuning. Fig. 2 shows a typical frequency characteristic of this type of detector

* Messrs. Nash & Thompson, Ltd.

relative to the characteristic of a tuned detector. The carriage of the standing wave detector is driven by rack and pinion, and a scale, graduated in guide wavelengths corresponding to free space wavelengths of 3.12, 3.20 and 3.26 cms. is provided to enable the phase of a mismatching impedance to be determined.

Equipment to be tested is connected to the bench by means of a special quick operation coupler which ensures proper alignment and good electrical contact. The rectangular version of the coupler is illustrated in Fig. 3.

The accessories provided with the bench include a dummy load, which is a reflectionless termination for the bench, a power comparator which, like the standing wave detector, covers a wide band and which serves to measure attenuation, three attenuators (10db., 3 db., and 1 db.), a pair of loads having a predetermined standing wave ratio, four rectangular and four circular couplers. A special tool for removing crystals from the standing wave detector or from the power comparator and two spare crystals are also provided in the carrying case.

In addition to the components carried in the case, a series of accessories are available to demonstrate the principles of waveguide propagation. These include the following:

(1) Short-circuited guide (adjustable plunger).

(2) Free space termination to match a waveguide into free space.

(3) Matching probe for matching any desired load to a waveguide.

(4) Rectangular 1 in. × ½ in. H_{01} mode to circular 1⅛ in. dia. H_{11} mode adaptors.

(5) Rotating joint which, when used with item 4, shows that propagation is altered by relative rotation of guide carrying H_{01} or H_{11} waves, and, when used with the special convertors supplied with the test bench, the propagation is unaffected if the mode is changed to E_{01}.

(6) A variable attenuator (0-10 db. or 0-30 db.) which provides an alternative means of attenuation measurement.

(7) A two-way changeover switch for making rapid comparisons between components under test.

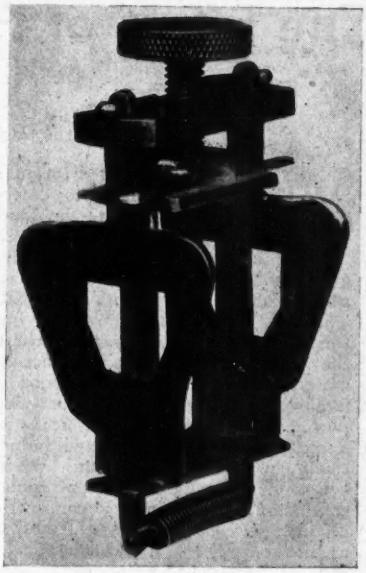


Fig. 3. Enlarged view of coupler for connecting equipment to test bench.

References

[1] Lord Rayleigh. *Phil. Mag.* 43, 1897.
[2] Willis Jackson and L. G. H. Huxley. "The Solution of Transmission Line Problems by use of the Circle Diagram of Impedance." *J.I.E.E.*, Pt. III, 91., 15.

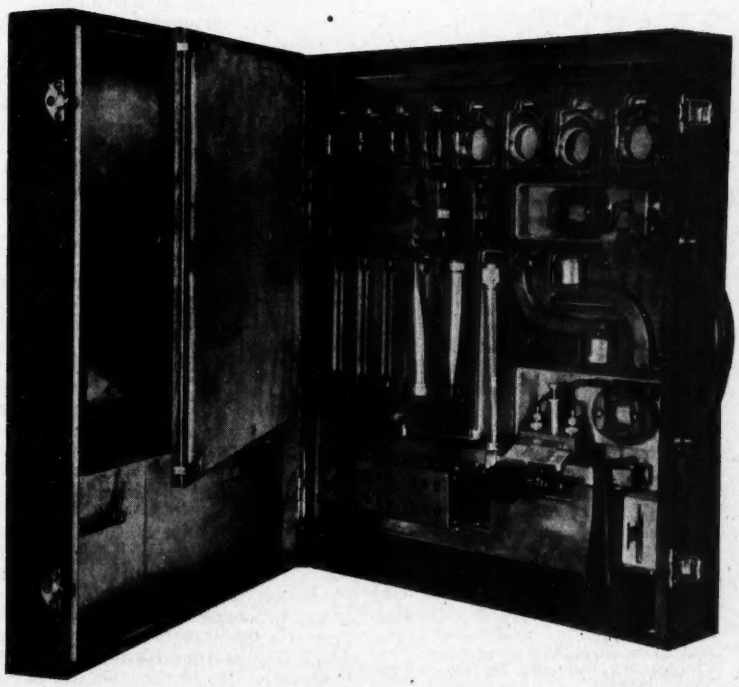
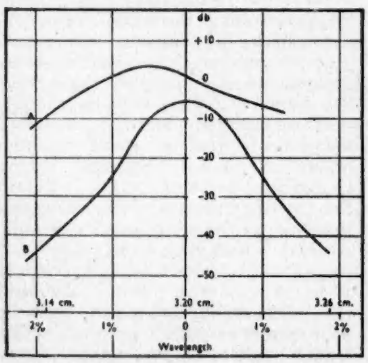


Fig. 4. Complete case of Equipment and accessories.

Fig. 2 (below). Comparative characteristics of standing wave detectors. (A) Wide band type. (B) Resonant type.



The Effect of Frequency in Induction Heating

By DR. R. A. NIELSON *

The article formed the first part of a paper read before the High Frequency Heating Conference sponsored by the Pacific Coast Electrical Association at Los Angeles, Cal., Dec. 1945

WHILE a complicated formula is frequently used to determine the watts into the load for induction heating, there is a method that is very understandable, yet one that gives a good approximation of the power into the load. The first step toward conceiving this method is to investigate where the current flows in a conducting material. Once this is understood it is an easy matter to comprehend why power is generated non-uniformly in a conducting material heated inductively by alternating current.

Consider, for example, a round conductor divided into 3 concentric circular sections marked A, B and C as shown in Fig. 1. Each section may be considered as an inductance and a resistance in series. Section A is linked by the flux generated by the total of the currents flowing in sections A, B and C; its inductance is, therefore, the maximum. Section B is linked by the flux due to the current flowing in B and C and by the flux from only part of the current in A; its inductance is, therefore, less than that of A. As section C links still less flux, its inductance is the minimum. If the restivity of the cylinder is uniform, the impedance of A is greater than that of B, which is in turn greater than that of C. Therefore, more current per unit of area will flow through C than through the interior parts of the cylinder. The current actually drops off exponentially from the surface as shown in Fig. 2.

Because the current tends to stay near the outer surface, this phenomenon is referred to as "skin effect." Fig. 2 applies for all frequencies; the only difference being that a different "distance scale" is used. In Fig. 3 a distance scale has been established in units of δ, the depth of penetration. Since the current curve is exponential, it is convenient to choose δ as the distance where the current is $1/e$ of its surface value $\left(\frac{1}{e} = \frac{1}{2.718} = .368\right)$.

At the distance 2δ, the current is $1/e$ of its value at δ, *i.e.*, = .135 of its surface value.

The heating effect or I^2R loss can also be determined by adding another scale to the ordinate of this curve. Thus the power generated at the distance δ from the surface is approximately $\frac{1}{8}$ of its surface value. In fact, 85 per cent. of the total heat generated in the cylinder, is generated in the region less than 1δ from the surface.

δ can be defined as follows:

$$\delta = 3170 \frac{\rho}{\mu . f} \text{ inches.}$$

where

ρ = resistivity of the cylinder (ohm-inches)

f = frequency in cycles

μ = permeability (equals unity for non-magnetic materials).

For a general illustration of induction heating, consider a 3-in. diameter cylinder surrounded by a work coil as shown in Fig. 4. Alternating current flowing in the work coil induces current to flow around the periphery of the cylinder, being a maximum at the surface and decreasing towards the centre according to the formula for the depth of penetration of the current.

By putting the values applicable in this example into our formula, it is possible to find out exactly where the current flows in the cylinder that is to be heated. For copper, at room temperature, and 60 c/s. current the depth is:

$$\delta = 3170 \sqrt{\frac{.66 \times 10^{-6}}{1 \times 60}} = .33 \text{ in.}$$

The current pattern is therefore as shown in Fig. 5, and 85 per cent. of the heat will be generated within $\frac{1}{3}$ in. of the surface.

It is frequently convenient to consider that all the current flowing around the piece is distributed uniformly across a section of thickness δ. Then, knowing the resistivity of the material and the average length of the current path, the power dissipated in the load can be calculated. This will give a value for power loss equivalent to that obtained by integrating the actual power loss over the entire cylinder. For example, in the case of the 3-in. copper cylinder, the depth of penetration was $\frac{1}{3}$ in. and the path length was the periphery of the cylinder. If a 1-in. length of the cylinder is considered, then the power dissipated is:

Watts per in. of cylinder length

$= I^2R$

$= (\text{Amps/inch of cylinder})^2 \times \frac{\text{periphery}}{\delta} \times \rho$

or if a path along the periphery only one inch long is considered;

W/in² into cylinder surface $= (\text{amps/in})^2 \times \rho/\delta$

$$\text{W/in}^2 = (\text{amp/in})^2 \times \rho \times \frac{1}{3170}$$

$$\sqrt{\frac{\mu . f}{\rho}} = (\text{amps/in})^2 \times 3.16 \times 10^{-4}$$

$\sqrt{\mu . f . \rho}$

The only unknown is the current flowing around the cylinder. In the foregoing example, if the cylinder is put into a long coil, it will act as a single-turnshorted secondary of a transformer, the primary of which is the work coil. In such a case the number of ampere-turns in the secondary equals those of the primary. The amperes per inch in the secondary will then equal the ampere-turns per inch of the primary. Thus, for a cylinder in a long coil it can be seen that the watts per square inch into the cylinder surface is independent of the cylinder size; *i.e.*, in a large cylinder the same current flows in a longer path, thus the larger the diameter of the cylinder, the greater the total heat generated.

If the copper cylinder is heated to 950° F., the only change that occurs is an increase in the resistivity of the copper by a factor of 3. This results in an increase in the depth of penetration and in the watts by a factor of $\sqrt{3}$; thus, there is more heat and it is generated more uniformly throughout the cylinder. It is true in general, that as the temperature of a non-magnetic load is increased, both the power into it and the depth of the heated zone increase. This is due to the fact that the resistivity of metals increases as the temperature rises.

Next consider an iron cylinder at room temperature, the resistivity of which is 4×10^{-6} ohm-inches and the permeability of which shall be arbitrarily assumed as 36. (The actual value of the permeability

* Manager, H.F. Laboratory, Westinghouse Electric Corpn., California.

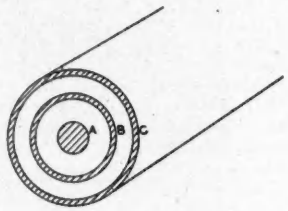


FIG. 1

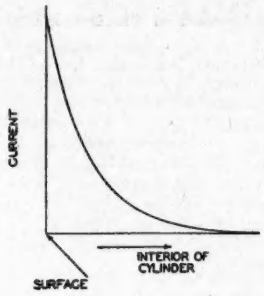


FIG. 2

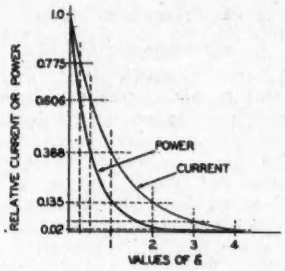


FIG. 3

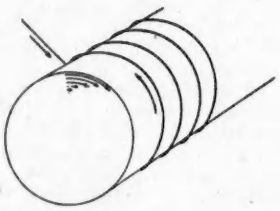


FIG. 4

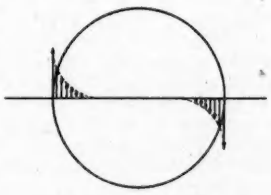


FIG. 5

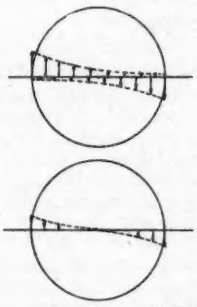


FIG. 6

depends upon the intensity of the magnetic field at the surface of the work; it is thus a function of shape, size, and current in the work coil.) The depth of penetration is .4 that of the copper cylinder (*i.e.*, .13 inches). However, a change of considerable magnitude has occurred for the power into the cylinder. The increased resistance and the permeability have both contributed to increase the power to almost 15 times that of the copper at room temperature. If this iron cylinder is heated to 1,300° F., the increase in resistance results in an increase in the depth of penetration and power input by a factor of 3. If the temperature is raised another 150° F., a sudden change occurs; the iron becomes non-magnetic and its permeability drops to unity. This results in an increase in the depth of penetration by a factor of 6 and a corresponding decrease in the power into the work. In the case of all magnetic materials, there occurs quite a sudden change of load as the material passes through the Curie temperature, which is the transformation temperature above which the material is non-magnetic.

As a final example, consider the depth of penetration for a three-inch cylinder of stainless steel, the resistivity of which is 13.5×10^{-6} ohm inches. The depth of penetration for 60 c/s. current is 1.5 inches. From Fig. 6 it can be seen that the depth of penetration is so deep into the cylinder that the current is far from negligible at its centre. The end result is an effective current as shown, and it is obvious that in this case the heating will be reduced considerably below that which was calculated by the formula. In this case, δ was equal to the radius of the cylinder. The smaller δ is compared with the diameter, the more accurate is the formula for power; but it can still be applied so long as δ remains less than $\frac{1}{4}$ the diameter. In cases where the material is not cylindrical, the formula also applies provided δ is less than $\frac{1}{3}$ the minimum dimension.

It has been shown where the heat is generated in a load as a function of the depth of penetration. The frequency, which so far has been 60 c/s., also affects the depth of penetration since the formula for δ contains the factor "square root of frequency." Thus, if the frequency is raised to 6,000 c/s., the depth of penetration would be decreased by a factor of 10; if the frequency is 600,000 c/s., the depth of penetration is 1/100 of its former value (*i.e.*, it is only .015 inches for the stainless steel cylinder).

So far the discussion has been confined to where the heat was generated; now a word about the end result. If a piece of metal is to be heated throughout its mass, it can be done in two ways: First, by high frequency, second, by low frequency. In the first case the heat is generated close to the surface of the piece and it takes time for the heat to soak into the interior parts; this may be a long time if the piece is large. In the second case, more of the heat will be generated in the deeper sections of the piece. This, of course, is the preferred way.

Frequently it is desired to heat an area locally, or to surface harden

something. Here it is convenient to use high frequency to generate the heat near the surface, and high power to shorten the time that the heat must be applied, for during this time the heat is being conducted away to the interior of the piece and a thick layer is being brought up to hardening temperature. In other words, case hardening can be done with high frequency and short time or with very high frequency and a somewhat longer time with lower power input. The question that immediately comes to mind is: Why not just keep raising the frequency so as to further localise the heat? This is done up to frequencies of about one million cycles per second. At frequencies above 1 megacycle technical difficulties arise. Though successful hardening has been done at 10 megacycles, 1 megacycle is generally considered as a working maximum for induction heating.

A word as to the nature of the difficulties encountered. So far a cylinder in a long solenoid has been considered. As the frequency is increased, the impedance of the work coil increases and eventually a limit is reached where even with a minimum of inductance in the work coil, the voltage between turns of the coil or the voltage between the coil and the work has become large enough to cause arcing. Technical difficulties arising from an attempt to get the required power into the work without arcing set the upper limit of frequency used for induction heating.

From the formula for watts into the load, it can be seen that the power increases as the square root of the frequency. Thus by increasing the frequency, the same heat can be put into the work using fewer turns or less current in the work coil. For example, heating at 600,000 c/s. requires 1/10 the ampere-turns required for the same heat input at 60 c/s. This large reduction in ampere-turns often greatly simplifies the design of coil used at the high frequencies since with small pieces or for heating local areas, the number of ampere-turns that can be coupled to the piece or area is often limited.

High-frequency induction heating finds many applications in heating of small metal pieces, and its thin depth of penetration indicates its use for case hardening. Where heavy sections are to be heated or hardened, or where a deep heat penetration is required, low frequency—sometimes even below 60 cycles—is used.

OCTOBER MEETINGS

Institution of Electrical Engineers

All meetings of the London Section will be held at The Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Radio Section

Date: October 9. Time: 5.30 p.m.
Inaugural Address as Chairman: Professor Willis Jackson, D.Sc., D. Phil.

Date: October 30. Time 5.30 p.m.
Symposium of papers on Direction-Finding.
By:
R. L. Smith-Rose, D.Sc., Ph.D., and W. Ross, M.A.

Cambridge and District Group

Date: October 8. Time: 6 p.m.
Held at:
The Cambridgeshire Technical College.
Chairman's Address:
"Radio from the Sun and Stars"
By:
J. A. Ratcliffe, O.B.E., M.A., M.I.E.E.

Date: October 29. Time: 6.30 p.m.
Held at:
University Engineering Laboratory.
Lecture: "Ground Radar."
By: D. Taylor, Ph.D.
Group Secretary:
D. H. Hughes, c/o Pye Ltd., Radio Works, Cambridge.

The Television Society

All meetings will be held at The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Date: October 29. Time: 6 p.m.
Lecture:
"An Improved Television Signal Generator and its Uses."
By:
F. H. Townsend, G. B. Goff, and S. R. Kharbanda.
Lecture Secretary:
G. Parr, 68, Compton Road, London N.21.

Institution of Electronics

North-West Branch

Date: October 18. Time: 6.30 p.m.
Held at:
The Reynolds Hall, College of Technology, Manchester.
Lecture: "Glass for Electron Tubes."
By: Dr. J. H. Partridge.
Tickets may be obtained from L. F. Berry, 105, Birch Avenue, Chadderton, Lancs.

Brit. I.R.E.

Date: October 17. Time: 6 p.m.
Held at:
The London School of Hygiene and Tropical Medicine, Keppel Street.
Lecture: "The Design and Application of Modern Permanent Magnets."
By: A. J. Tyrrell.
The Secretary:
The British Institution of Radio Engineers, 9, Bedford Square, W.C.1.

German Infra-Red Technique

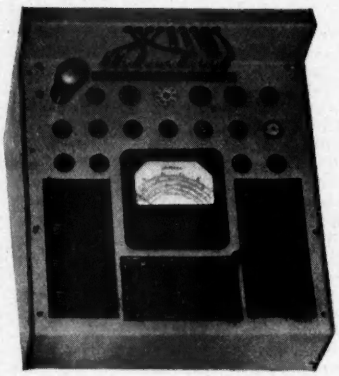
(*Continued from page* 317)

component, the scanned image can be made visible on a fluorescent screen of a cathode-ray oscillograph.

Another instrument is a so-called "electron mirror." It also uses a photo-sensitive semi-conducting layer, the local resistance of which would change according to the intensity of the illumination. When the layer is bombarded by a broad electron beam, then the local parts having higher resistance than their surroundings would soon acquire a negative charge, which would repel, or "reflect" further incoming electrons, whereas regions of lower resistance would conduct the incoming electrons away. The illuminated sensitive layer is thus bombarded by electrons accelerated by a variable voltage modulated between 5-6 kV. The electrons reflected from the regions of a high resistance are then focused on a fluorescent screen, where the image is viewed. The layers must have a comparatively high resistance, so that PbS and PbSe, which have too low resistance, are unsuitable. They can, however, be built in a layer of PbO, which is a good insulator. They can be prepared by a simultaneous deposition of PbO and S on a glass surface heated to about 150° C. The layer is then ripened in air at 300°-320° C. A mixture of PbS embedded in PbO is probably formed, but as many intermediate compounds, the chemistry of which is not yet sufficiently known, may be formed, optimum conditions must be found by experiment. The layers have a high resistance, a negligible inertia and are sensitive up to 2.5 μ. An irradiation by 10^{-5} watt/mm^2 decreases their resistance tenfold. ZnO layers deposited on a Mn mirror were also used, after being heat-treated in sulphur vapour at 60°-70° C., and ripened at 400° C. in air, when they turn from orange-red to brown. Very good layers were also prepared by evaporation of ZnO at a comparatively high pressure of 100 mm Hg, which gives them a coarse crystalline structure.

The infra-red devices will be probably considerably cheaper than the radar equipment, so that it is hoped that they will find extensive use in the peace-time in guiding transport in darkness, safeguarding against collisions. There would also be applications in physics and astronomy, which would further extend our knowledge of the matter and of the universe. It is hoped that more precise information on the manufacture and properties of the sensitive layers will be soon available.

NOTES FROM THE INDUSTRY



A New Service Valve Tester

This equipment, designed by Everett Edgcumbe and Co., Ltd., Colindale Works, London, N.W.9, incorporates the following features: variable D.C. supplies for anode, screen and control grid; measurement of emission and mutual conductance; separate rectifier and diode emission measurement; detection of grid current and low vacuum; hot cathode heater insulation test; inter-electrode insulation test; thyratron emission and control ratio measurement.

By means of the variable D.C. supplies, it is possible to simulate the manufacturer's test conditions, the published data conditions or the conditions applying to the valve in use.

The tester is fitted with one valve holder of each type in general use with spare spaces for new patterns, and the connexions from the valve to the tester are by means of plugs and sockets numbered to conform to the B.V.A. code.

A 4-in. moving coil indicator is embodied, and if required an all-purpose tester control panel to give multi-range A.C. and D.C. measuring facilities may also be fitted.

The price of the tester is £19 15s., and with the all-purpose control panel, £28 17s. 6d.

Marconi-Pye Agreement

An agreement has been concluded between these two companies for the joint peacetime design, manufacture and sale of a V.H.F., radio landing system for aircraft. The equipment, which has been recommended for international adoption, will be manufactured by Pye, Ltd., and sold, installed and maintained by Marconi.

Morgan's at War

One of the best war record publications we have yet seen is "Morgan's at War," the story of the Morgan Crucible Company, Ltd., from 1939-1945. Attractively reproduced in gravure, it is a bound book of 76 pages, with the reproduction of a captured German map as dust jacket.

The book is vividly illustrated with photographs depicting each phase of the war, and a colour insert specially prepared by the Isotype Institute, illustrates how directly and indirectly Morgan products were used in the production of equipment for aircraft, armoured vehicles, guns, shells, radar equipment, etc.

Acid-resisting Cement

J. H. Sankey and Son, Ltd., Ilford, Essex, have issued a new leaflet concerning their super acid-resisting cement. The cement is supplied in the form of a fine powder which, when mixed with acid-resisting solution, forms a plastic cement for use in bedding and jointing vitrified bricks and tiles in the construction of acid-resisting floors, walls and tanks. It sets in 12 hours, withstands temperatures up to 1,200° C., is water-resisting, can be stored any length of time without deterioration, and has exceptional tensile strength. It is stressed that the acid-resisting cement should not be used as a rendering to floors, etc., in the same way as Portland cement.

"The Transmitting Licence"

This is not a technical publication but a useful booklet issued by the Radio Society of Great Britain, price 9d., which presents in a convenient form the salient information required by those who wish to obtain an amateur transmitting licence.

It should be of particular interest to the Service personnel who during the war years have acquired a basic knowledge of the theory and practice of radio-communication, and now wish to enter the field of amateur radio.

The G.P.O. have released further frequencies for the use of amateur transmitters. They may now transmit on 1715-2000 kc/s. (power limited to 10 watts input)), 3500-3635 kc/s. and 3685-3800 kc/s. (power limits as for 7,14 and 28 mc/s., namely: class A, 25 watts and class B, 150 watts.)

G.E.C. Appointment

Mr. J. Baggs, Assoc.I.E.E., and a member of the Measurements Group I.E.E., N.W. Centre, has been appointed to the sales organisation of The General Electric Company, Ltd., at Victoria Bridge, Manchester, as Industrial Electronic Instrument Engineer for the N.W. area. For the past eight years, Mr. Baggs has been at the Salford works.

Adam Hilger, Ltd.

Mr. Frank Twyman, F.Inst.P., F.R.S., has resigned his position as managing director of Adam Hilger, Ltd., to become technical adviser to the firm and to their associates, E. R. Watts & Son, Ltd. He is succeeded by Mr. G. A. Whipple, M.A., M.I.E.E., F.Inst.P., who is also managing director of E. R. Watts.

The Plessey Co., Ltd.

The Plessey Co., Ltd., announce that Major H. G. Faulkner, M.B.E., who was a wireless staff officer in the Royal Signals during the war, has been appointed radio components sales manager as from August 26

British Electronic Products, Ltd.

Two new directors, Mr. H. W. Mitchell and Mr. R. A. Bent, have been appointed to the board of this company, recently formed for the development and production of industrial electronic equipment, including electromedical apparatus. Both directors were formerly with the English Electric Co., Ltd.

R.F. Equipment, Limited

Mr. M. Reed, Ph.D., M.Sc., M.I.E.E., has been appointed general manager of the Radio Division of R.F. Equipment, Ltd., manufacturers of Sobell Radio, in control of production and engineering.

South-East London Technical Institute
Electrical Engineering Department

A course of about 30 lectures on "Communication Circuit Network Calculations" (Theory and Practical Design Methods), by Dr. W. Saraga, Ph.D., on Mondays, 7-9 p.m., commences on October 7, 1946. Fee for the course, £1. Applications for admission should be made to the Head of the Electrical Engineering Department, South-East London Technical Institute, Lewisham Way, London, S.E.4, as early as possible and before Friday, October 4, 1946.

BOOK REVIEWS

High-Frequency Induction Heating

F. W. Curtis. McGraw-Hill, N.Y. 1944. Price in Britain, 16s. 6d. 235 pp. 249 Figs. and Photographs.

This book has taken over a year to reach Britain, and, as the first text on the subject since Burch and Davis (Theory of Eddy-Current Heating, 1928), it will be eagerly welcomed by all those who are applying the rapidly advancing production technique of induction heating. The author, as a consulting engineer who has made several original contributions to the art, is well qualified to deal with the subject and has produced a thoroughly practical, lavishly illustrated work which incorporates all the major developments of recent years, largely stimulated by more efficient and reliable high-frequency generators. Since the art of induction heating is in applying it to specific workpieces, mechanical rather than electrical topics dominate the book.

The first chapter deals broadly with principles, including the mechanism of heat production in a metal, thermal and power requirements, the importance of frequency, comparison between induction and dielectric heating, measuring generator power output, heat transfer and surface heating due to skin effect, coil materials, losses in magnetic as against non-magnetic materials and critical temperature in magnetic materials. Representative parts for localised hardening are shown, also general types of coils including contouring, narrow versus wide coils, insulation and basic rules for coil selection. It is unfortunate that the theory is sometimes badly expressed or even erroneous, *e.g.*, " resistance of the work being its *inability* to carry the induced current", " This (high-frequency) current sets up a field of magnetic flux which *flows around the surface of the work in the opposite direction,*" and " a dielectric generator cannot be used for metallic parts because of the *voltage breakdown* that would occur". These statements, while not deceiving the electrical engineer, will be very confusing to others trying to understand the electrical principles involved. This part of the book needs to be thoroughly revised and expanded.

Types of h.f. equipment are basically motor-generator sets (2-9.6 kc/s.), spark-gap converters (25-250 kc/s.) and electronic oscillators (100 kc/s. and above). A given unit has a definite working range of part sizes. General circuits, panels and layouts of representative units are shown, with notes on control and protection and illustrations of melting and forging.

Coil design, most important feature of any practical job, is discussed in relation to coupling and heat localising, covering single and multiturn coils, special shapes and sections, internal and external heating, tapered surfaces. Special considerations include prevention of overheating, limits to coil length and uneven heating, inductance losses, heat patterns due to coil pitch, eccentricity, etc., split coils and the use of copper inserts to prevent overheating in slots and holes. Multiple operation coils, " solid " coils, parallel-bar inductors (especially for conveyor work) and several miscellaneous types are described, as well as flexible leads, insulation and supports.

Brazing, soldering and joining is a particular field in which new manufacturing techniques such as fabrication are possible with induction heating, giving speed, uniformity and economic local heating with less distortion than older methods. Silver alloys are particularly suitable. Brazed joints, methods of applying the alloy, setups and joint strength are discussed. Other topics include copper brazing in hydrogen, conveyor soldering and brazing, and tool brazing.

Induction hardening and heat treating are of particular advantage when localised surfaces are to be dealt with, as deformation, warping and scale are eliminated and machining is often possible *before* treatment. Hardening tables and (plastic) quench rings are described with general applications. Progressive heating and quenching are used for long surfaces or continuous feeding. Considerable details on gear-hardening are given, with other notes on high-speed steel structure, crankshafts, air hardening, oil spray and surface hardening *under* oil. An impressive summary of advantages of the technique concludes the chapter.

Fixtures, depending on the quantity of production desired, may be simple, single or multiple jigs, sliding or rotary platforms or continuous feed systems. The importance of spacing away metal parts and using non-metallic materials is emphasised.

Miscellaneous applications of induction heating include out-gassing of vacuum tubes, annealing, forging (a particular advantage being no scale to deteriorate press tools), spinning, flowing tinplate, straightening shafts, melting (one generator supplying alternative crucibles) and vacuum sintering. Other uses are for paint drying, breaking rubber/metal bonds without damage and centrifugal casting of small precision parts. Quenching release mechanisms and conveyors and photo-electric temperature control are described.

In designing for induction heating, examples are given of practical modifications and of fabricated parts (replacing forgings) which take the best advantage of the process.

A final chapter on dielectric heating has been added to point the contrast between the two " field " methods of heating. General theory is followed by a description of typical generators, comparison with hot plates, preform heating, power requirements, wood drying and dehydration. More material on this subject would have been welcome, but for treatment comparable with the rest of this work it would double the size of the book.

The arrangement of material within the chapters is inclined to be jerky, theoretical and practical topics being sometimes mixed, and there is some overlapping between chapters. Despite the spate of literature on RF developments since 1941, no references are quoted. These criticisms, however, may seem small in view of the original and stimulating nature of the work, which should be read by all designers and production engineers. As a record of what has *already* been accomplished, it indicates a very bright future for induction heating.

J. C. FINLAY

Books reviewed in this Journal can be obtained from

H. K. LEWIS & Co. Ltd.

136 Gower Street, W.C.1

If not in stock, they will be obtained from the Publishers when available

Electric Discharge Lamps

H. Cotton. Vol. xii, Monographs on Electrical Engineering. (Chapman & Hall, London, 1946). 36s. xiii + 435 pp. 216 figs.

This is the latest addition to the series of monographs on electrical engineering published by Chapman and Hall, under the editorship of Mr. H. P. Young. The inclusion of a volume dealing with electric discharge lamps in this well-known series is an event to be welcomed.

The development of discharge lamps has followed two main lines: firstly, lamps of the high-pressure mercury vapour and sodium vapour types, where the discharge itself provides directly the bulk of the light and where the advantages of high luminous flux and high efficiency are associated with relatively small source size. In such lamps the spectral quality of the light is mainly a characteristic of the discharge and can be controlled only to a very limited extent.

Secondly, sources whose light is largely emitted by a thin layer of powder excited to luminescence by the ultra-violet radiation from the discharge. The efficiency of light production is of the same order as in the first type, but because of the requirement of low temperature operation, the lamp is large in relation to its luminous output. The important feature

of these lamps is that the light from the luminescent coating is spectrally continuous like that of sunlight or tungsten filament lamps; their excellent colour rendering characteristics and high efficiency make these fluorescent lamps ideal for general lighting purposes, and their use is rapidly becoming widespread.

In the book under review, the author has dealt with both these classes of discharge lamps in a chapter on Practical Forms of Discharge Lamp which, with a short chapter on Control of Electric Discharge Lamps, comprises approximately one-third of the book. The remainder of the book is concerned with a number of fundamental matters which relate more or less directly to discharge lamps such as Radiation, The Structure of the Atom, Motion of Electrons and Gas Particles, Atomic Spectra, and The Structure of Spectral Lines. There are also chapters on Thermionic Emission, Discharge Phenomena, Fluorescence and Colour.

In his preface, the author remarks: " At the present time the vast majority of lighting installations . . . are carried out with temperature radiation sources, and the mental background of the illuminating engineer has been conditioned by long acquaintance with this type . . reorientation of outlook is not only desirable but necessary, and it is to be hoped that this treatise will be of assistance in bringing about this change."

We think the illuminating engineer may safely be left to adapt his outlook to the new medium. What is likely to be more difficult is to ensure that the user is equally adaptable; the average individual is highly conservative in such matters as lighting and new light sources come in for a considerable measure of critical, and not always too well informed, comment. Unfortunately, the present volume is not likely to help the man in the street in his understanding of modern light sources.

The illuminating engineer to whom, presumably, the book is primarily addressed, will probably view with mixed feelings the college-text-book style of the treatment; the student may consider that the fundamentals can better be studied in more formal text-books, while the expert may feel that some of the arguments lack conviction and that the impression is sometimes given that the author has not always succeeded in convincing himself. It is perhaps the general technical reader who is likely to find the book most informative and interesting.

The author has collected his material from divers sources and his acknowledgements are full and proper. The numerous figures are well considered and these, together with an ample bibliography, add greatly to the value of the book.

It may be said that the book has its faults and its errors. But if there is much to criticise, there is also much to admire, and Professor Cotton and the publishers are to be congratulated on producing a volume which is both readable and stimulating and which meets a real need.

H. G. JENKINS

Manual of Electro-encephalography for Technicians

By R. S. Ogilvie. (Addison—Wesley Press, Cambridge, Mass). 100 pp., 43 figs. 21s.

Only one book having appeared in the English language on Electro-encephalography, the publication of the second calls for discussion, though it has no other claim on the attention. Whether there is a place for a book directed only to EEG technicians is open to question; if written at all it should concern itself with purely technical matters and deal with them adequately and not, as here, range over the whole subject with a superficiality which is inevitable in 70 pages of circumlocutory text. It must be presumed that the author hoped to find a less critical audience among technicians than among their principals.

Allowing for the fact that he has attempted more than he is equipped to fulfil, there remain a narrow parochial outlook, muddled phraseology, and uncritical thought which are inexcusable. An example of the first is the unawareness of the utility of pad electrodes, or of the importance of non-polarisability in electrodes. Other short lapses may be quoted, though they can only suggest the longer inadequacies. " Local laboratory terminology and abbreviations are not acceptable in electro-encephalographic reports," yet on the same page: " The degree of response to over-ventilation should be reported as ' No build-up,' ' Slight build-up,' or ' Big build-up.' " Frequency is " measured by the time which elapses from trough to trough." A " steady rate per second " is perhaps tautological rather than accelerational.

The following is the total information on " Circuits ": " A circuit is a complete path along which electric current can flow. It may be either a direct current or alternating current circuit, or in some cases a combination of both. An active, or closed circuit consists of a source of energy connected to some device which translates the energy into work. An open circuit is one through which no current flows." The above quotation forms a part of a 9½ page appendix, in which are discussed EEG recorders, electricity, A.C. and D.C. sine waves, brain waves, vacuum tubes and the C.R.O. Perhaps it is as well for the digestion that this hasty hash contains so little meat.

The author is singularly fortunate, for he is able to dismiss " Trouble Shooting " with equal brevity, in 2½ pages, nearly half of which are devoted to " Low Batteries " and " Carelessness." On " Defective Tubes " he says: " A common defect in a worn-out tube is the production of what is called a noise level! "

The publishers would have been better advised to devote their obvious competence some worthier object, and one more deserving of the charge of a guinea.

W. A. COBB

MELTON METALLURGICAL LABORATORIES LTD.

Liquid Silver

Platinum & Gold Solutions

For Metallising Mica Ceramic Quartz etc.

Low Melting Point Solder and Non - Corrosive Liquid Flux (A.I.D. Approved)

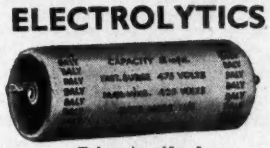
IPSWICH ROAD TRADING ESTATE SLOUGH, BUCKS.

'Phone: Slough 20992

Agents for Australia:
A. S. HARRISON & CO. PTY. LTD.
85 CLARENCE STREET, SYDNEY

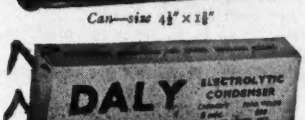
DALY

ELECTROLYTICS



Tube—size 2½" × 1"

Can—size 4½" × 1⅞"



Block—size 4⅛" × 1¼"

The DALY range covers all requirements

Note—All Condensers bear the date made

DALY (CONDENSERS) LTD

Condenser Specialists for over 20 years

West Lodge Works, The Green, Ealing, W5

'Phone—Ealing 4841

ABSTRACTS OF ELECTRONIC LITERATURE

ELECTRON OPTICS

On the Improvement of Resolution in Electron Diffraction Cameras

(J. Hillier and R. F. Baker)

An electron optical system is described in which it is possible to obtain (1) high resolution electron diffraction patterns, (2) shadow electron microscope images, and (3) electron diffraction patterns of selected variable areas of the specimen. The change in mode of operation of the system is accomplished by electrical adjustments without changing the specimen position in any way. A number of phenomena related to the attainment of high resolution diffraction patterns are described. Pertinent details of the experimental apparatus are discussed and some representative results are shown.

—*Jour. App. Phys.*, Vol. 17, January, 1946.

MEASUREMENT

The Measurement of Impedances, particularly of Decimetre Waves

(J. M. van Hofweegen)

Several methods are discussed by which impedances can be measured at radio frequencies. At wavelengths above 1 metre it is customary to connect the impedance to be measured in parallel with an oscillation circuit, and to calculate the required impedance from the detuning and damping influence experienced by the circuit. On decimetre waves a Lecher system is used as oscillation circuit. This article describes the manner in which this method has been worked out in the Phillips Laboratory. As measuring instrument for the high-frequency voltage a diode voltmeter needing only relative calibration is used.

—*Philips Technical Review*, January, 1946, p. 16.

Suppressed-Range Recording Peak Voltmeter

(F. G. Brockman)

A recording peak voltmeter of the suppressed-range type is described. The minimum detectable voltage change is 10^{-3} volt, so that with an input of 10 volts r.m.s. average amplitude fluctuations of 0.01 per cent. can be recorded.

—*Rev. Sci. Inst.*, Vol. 17, May, 1946, p. 177.

Applications of Unbound Resistance Gauges

(R. D. Meyer)

The author discusses the mathematical aspects of resistance wire strain gauges and their application to measurement of pressure, acceleration, force and weight by way of introduction to unbonded-wire gauges. In the latter, four windings of strain sensitive wire are wound round rigid pins which are caused to move slightly with relation to one another by longitudinal movement of an armature. These four windings comprise the four elements of a Wheatstone bridge, movement increasing the strain on one pair of windings and decreasing that on the other pair. This gauge functions as a dynamometer or as a strain gauge. If a weight is fastened to the armature, the gauge becomes an accelerometer; if a metallic bellows or diaphragm is connected to the armature, the unit becomes a pressure transmitter.

—*Instruments*, March, 1946, p. 136.*

INDUSTRY

Merchant Marine Radar

(I. F. Byrnes)

This paper outlines and discusses surface search radar for maritime application. Such applications require high performance, including good bearing and range resolution to pick up buoys, other vessels and shore lines when navigating in restricted waters. Fundamental aspects of transmitter, receiver, indicator, and antenna design are discussed. The effect on range due to reflexions from the sea, which produce a lobe structure, are described, and the advantages of using very high frequencies to obtain the best formance are pointed out. Range calculations and the importance of adequate power for reliable operation under adverse conditions are considered.

—*R.C.A. Review*, Vol. 7, March, 1946, p. 54.

Scale Glass as a Substitute for Mica

(J. M. Stevels)

Details are given of a new product which was originally developed with the aim of finding a substitute for mica in radio valves. The product is composed of glass scales held together due to the fact that two glass plates which are optically flat, can cohere so perfectly that they cannot be separated. The method of building up the scales into thick plate is indicated, and it is found that the product fulfills all the essential conditions required for such a substitute. Other applications of this insulator include use in heating elements of domestic appliances and as a thermal insulator.

—*Philips Research Reports*, January, 1946, p. 129.*

Gradient Microphones

(H. F. Olson)

The response-frequency and directional characteristics of gradient microphones from zero to *n*th order have been obtained. Higher order unidirectional microphones have also been developed. The directivity increases with the order, which means a corresponding discrimination against random sound. The accentuation of the low frequency response, when the distance from a small source is less than a wavelength, increases with the order and the wavelength. This feature may be used to obtain high discrimination against distant sounds in a close talking microphone. The amount of discrimination increases with the order of the microphone.

—*Jour. Acous. Soc. Am.*, Vol. 17, January, 1946.

Electrical Resistance Wire Strain Gauges

(F. Aughtie)

The general principles of operation of the electrical resistance wire strain gauge are reviewed and different forms of construction, glues for use with gauges, and bridge circuits for measurement of static strain are discussed. The problem of measurement of non-static strains necessitates the use of valve amplifiers, and attention is drawn to possible sources of distortion. Throughout the paper, possible sources of error are emphasised and necessary precautions are suggested. The paper is concluded with a reference to dynamic use, such as in "quick transients" and rapid cyclic phenomena, and methods of calibrating the equipment are reviewed. The discussion before the Institution and the author's reply are appended.

—*Trans. Inst. Mar. Engrs.*, May, 1946, p. 59.*

The Silvering of Plastics

(H. Narcus)

A method of plating plastics is described in which the conductive silver film is produced, on a properly cleaned and "sensitised" plastic surface, by chemically reducing an ammoniacal solution of silver nitrate by means of a reducing agent. Methods of cleaning and "sensitising" the surface are outlined and formulae for the ammoniacal silver nitrate solution and the reducing solution of formaldehyde are recorded. Advantages of the chemical reduction method are presented. It is claimed that these plated plastics combine all the inherent advantages of the plastics and the required properties of the metal coating. The net result is a combination of conductor and non-conductor which may have a wide use in electronics.

—*Metal Finish*, June, 1946, p. 240.*

Sintered Glass

(E. G. Dorgelo)

In the manufacture of certain articles in which many metal parts (*e.g.*, leading-in wires) must be fused into glass close to each other, it is sometimes impossible, due to the too low fluidity of the molten glass, to force the drop of glass between the metal parts. In such a case, glass in powder form can be used, and this can be introduced between the metal parts before fusing. The glass obtained after fusing, which is not completely clear, is called sintered glass, and contains many very small air bubbles. In this article various properties and possibilities of this glass are discussed.

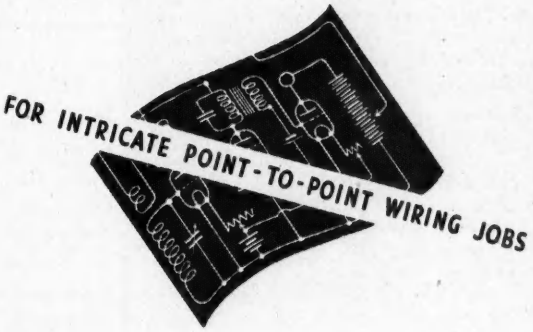
—*Philips Technical Review*, January, 1946, p. 2.

* Abstracts supplied by the courtesy of Metropolitan Vickers Electrical Co. Ltd., Trafford Park, Manchester

In twilight arctic or blazing tropic . . . across the trackless wastes of the world you know where you are with . . .

MARCONI

MARCONI'S WIRELESS TELEGRAPH CO. LTD. THE MARCONI INTERNATIONAL MARINE COMMUNICATION CO., LTD.
MARCONI HOUSE, CHELMSFORD, ESSEX.



Available in solid and stranded tinned copper conductors with rubber insulation, HAMOFIL wires are specially designed for efficient, economical wiring of electrical, radio and electronic apparatus.

A popular inexpensive grade known as HAMOFIL "Push Back" permits the cotton braiding to be slid back along the wire to facilitate joining or soldering.

Seven colours—Plain and striped.

Hamofil
CONNECTING WIRES
STRANDED SINGLE

De La Rue Insulation Limited
IMPERIAL HOUSE · REGENT STREET · LONDON W.1 · ENGLAND
Tel.: REGent 2901 Cables: Delinsul, Piccy, London

DAGA(46)

A Range of Miniature Vacuum Tubes

— *Raytheon Mfg. Co.*

Details of sub-miniature vacuum tubes only 1 9/16 in. long have been released by Raytheon Manufacturing Co., Newton, Mass.

Each tube in the series has the same physical dimensions, measuring 1 9/16 in. by 0.400 in. by 0.33 in., yet the converter has nine active surfaces between the two glass walls which are only ¼ in. apart. Weights of individual tubes vary between .07 and 0.09 oz., depending upon the type of tube. They may be mounted directly by their leads which will easily support the tube body, or by using commercially available sockets.

Filament types of Flat Hearing-Aid Tubes.

		CK502AX Pentode output type	CK503AX Pentode output type	CK505AX Pentode voltage amplifier type	CK506AX Pentode output type	CK507AX Pentode output type
Filament voltage ...	D.C. volts ...	1.25	1.25	0.625	1.25	1.25
Filament current ...	Milliamperes	30	30	30	45	45
Anode voltage ...	Volts ...	45	45	30	45	45
Screen voltage ...	Volts ...	45	45	30	45	45
Control grid ...	Voltage volts	—1.25	—2.0	0	—4.5	—2.0
Mutual conductance	*Micromhos ...	550	550	175	500	575
Anode resistance...	*Megohms ...	0.2	0.35	1	0.12	0.3
Load resistance ...	Megohms ...	0.1	0.05	1	0.03	0.05
Power output ...	Milliwatts ...	6	9.5		25	11

* These valves apply to measurements made at zero anode and screen resistance.

The types listed are as follows, the filament voltage being 1.25 in each case:

2.E.32.—Shielded pentode with sharp cut-off. I_f 50 mA. I_k 1.0 mA. max. At 22.5 V anode and screen, the transconductance is 500 μmhos and the anode current 0.4 mA.

2.E.36.—Power pentode. I_f 30 mA. I_k 1.0 mA. max. At 22.5 V the power output is 1.2 mW with 10 per cent. distortion. Load resistance 0.15 meg.

2.E.42. — Diode-pentode detector-amplifier. I_f 30 mA. Transconductance 375 μmhos. Diode current 0.25 mA continuous. Voltage gain (R.-C. coupling) 20.

2.G.22.—Triode-heptode frequency changer. I_f 50 mA. I_k total 2.0 mA. Conversion transconductance 60 μmhos. I_a (hept.) 200 μA. I_a (triode) 1 mA.

In addition to the above, the table shows a range of flat hearing-aid tubes measuring 1½ in. max. by 0.385 in. wide by 0.285 in. thick. In all tubes the leads are identified by a red mark over the anode lead.

ERSIN MULTICORE

Multicore Solder contains 3 cores of extra active non-corrosive Ersin Flux. No extra flux is required and joints can be readily made on oxidised surfaces. The three cores of Ersin Multicore ensure rapid melting and flux continuity, thus speeding up soldering operations and eliminating waste.

NOMINAL 1-lb. REELS HIGH TIN CONTENT PRE-WAR QUALITY.				
Catalogue Reference No.	Alloy Tin/Lead	S.W.G.	Approx. Length per nominal 1-lb. reel.	Price per nominal 1-lb. reel (subject).
16014	60/40	14	64 feet	6/-
16018	60/40	18	178 feet	6/9

Pure tin and lead used in Multicore Solder ensures uniform high quality.

High Precision standard of soldered joints obtained with Multicore.

This machine enables Multicore to be made in gauges between 10 and 22 S.W.G.

MULTICORE SOLDERS LTD., MELLIER HOUSE, ALBEMARLE STREET, LONDON, W.1

Tel. REGent 1411 (P.B.X. 4 lines)

EL

P
T

CI
W

M

B
THE BRITIS

B T-H

VALVES
for
ELECTRONIC CONTROL

Photo-cells, Ignitrons
Thyatrons, Rectifiers
Safety Gaps

• •

VALVES
for the
CENTIMETRE WAVE BAND

Magnetrons, Klystrons
Crystal Rectifiers

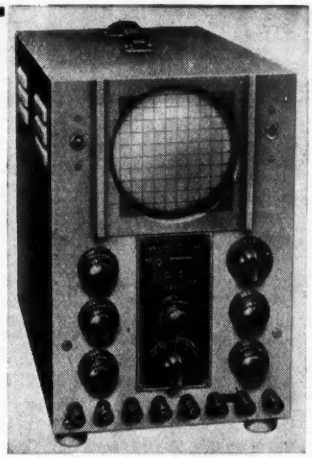
• •

Please send details of your requirements to:

BTH RUGBY

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, RUGBY, ENGLAND

A96:8V



***STATIC TWO-DIMENSIONAL** visual delineation of any recurrent law.*

•

***RELATIVE TIMING OF EVENTS** and other comparative measurements with extreme accuracy.*

•

***PHOTOGRAPHIC RECORDING** of transient phenomena.*

•

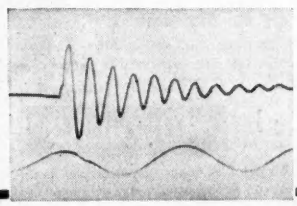
***SIMULTANEOUS INDICATION** of two variables on a common time axis*

INDUSTRIAL INDICATING and TESTING afford increasing scope for the Cathode Ray Tube as the only device with the above inherent features, of which the last is unique in the Cossor DOUBLE BEAM Tube.

The **Model 339 Cossor Oscillograph** thus equipped is invaluable on all problems of research, production or operational testing, when the effect examined is applied as a voltage. When recurrent the traces are studied visually and when transient are recorded photographically, using Model 427 camera.

A. C. COSSOR Ltd.,

INSTRUMENT DEPT.
Cossor House, Highbury Grove, London, N.5
'Phone: CANonbury 1234 (33 lines).
'Grams: Amplifiers Phone London.



TAYLOR *for the Best in Test Equipment*

MODEL 85A

UNIVERSAL TAYLORMETER

1. 90 Ranges.
2. 20,000 ohms per volt A.C. and D.C.
3. Improved Taylor Model 400 Meter with 4″ scale and robust movement.
4. Automatic Meter overload protection.
5. Volt readings from .001 volt D.C. and 0.1 volt A.C. up to 5,000 volts D.C. and A.C.
6. Current readings from 1 microampere to 10 amperes D.C. and A.C.
7. Resistance readings from 0.1 ohm. to 20 megohms in three ranges with self-contained batteries.
8. Capacity readings from .0002 to 100 mfd. and Inductance readings from 0.2 to 1,000 Henries, with Adaptor.
9. Buzzer for continuity tests.
10. Size 10½″ x 7½″ x 4¾″. Weight 5 lbs.

Price £19 . 19 . 0

Please write for illustrated leaflet

TAYLOR MODEL 85A is an extremely sensitive yet robust instrument with a high standard of accuracy. Meter overload protection is provided, ensuring reliable and trouble-free operation.

Taylor Electrical Instruments Ltd.

419-424 MONTROSE AVENUE, SLOUGH, BUCKINGHAMSHIRE

Tel: Slough 21381 (4 lines) Grams: "Taylins" Slough

VARIABLE AIR CONDENSER TYPE A—430

A component for building into your own measuring equipment or an instrument for use on the bench.

Light, rigid construction, smooth, even control and small electrical losses are qualities which you will look for and find in these Condensers.

They are available in aluminium boxes of MUNIT construction for bench use or with cylindrical metal covers for panel mounting.

SPECIFICATION

CONSTRUCTION Aluminium throughout.
CAPACITANCE LAW S.L.C.
INSULATION Frequentite.
BEARING Sprung ballraces and a frictionpad.
DRIVE Direct or 50 : 1 reduction.
SCALE 4″ dia. silvered.
CAPACITANCES From 100 $\mu\mu$F to 1,000 $\mu\mu$F.

Bulletin B-236-E, giving full particulars of these instruments, will be supplied on request.

MUIRHEAD

Muirhead & Company Ltd. Elmers End, Beckenham, Kent. Tel. Beckenham 0041-2.

FOR OVER 60 YEARS DESIGNERS & MAKERS OF PRECISION INSTRUMENTS

O.B.O. 33.

Dainite
MOULDED RUBBER SERVICE
Invite inquiries. Advice given on rubber formulas for special requirements.
THE HARBORO RUBBER CO. LTD. MARKET HARBOROUGH

BRAY CERAMIC INSULATORS

for L.F. and H.F. Components: also capacitor dielectrics

made by

GEO. BRAY & CO., LTD. LEEDS, 2

Established 1863 Phone Leeds 20981

CLASSIFIED ANNOUNCEMENTS

The charge for miscellaneous advertisements on this page is 12 words or less, 4/- and 4d. for every additional word. Box numbers count as four words, plus 1/- extra for replies. Remittance should accompany advertisement. Cheques and P.O.'s payable to Hulton Press, Ltd., 43 Shoe Lane, E.C.4. Replies to box numbers should be addressed as above, marked "Elec. Engg." Press date: 15th of month for following issue.

FOR SALE

IN STOCK. Rectifiers, Accumulator Chargers, Rotary Converters, P.A. Amplifiers, Mikes, Mains Transformers, Speakers of most types, Test Meters, etc. Special Transformers quoted for.—University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

ELECTRIC LIGHT glass multi fittings and a good selection of radio and electrical spares at a low cost. S.A.E. for list to Dioptrical Vision Aerial Co., 17, Mill Hill, Deal, Kent.

FULL RANGE of BPL instruments in stock. SAE brings you leaflets on these and all other components. M.O.S., 24, New Road, London, E.1.

MOVING COIL METERS, ex-Air Ministry, new condition, scale 30 m.a. D.C., movement 5 m.a. shunted, 2 in. dia., by leading makers, Weston, Ferranti, etc. each 15s., postage 6d. extra. Stamford Radio Co., 199, Stamford Street, Ashton-under-Lyne.

PHOTO ELECTRIC ORGAN patents for sale or licence: the simplest possible system of organ building based on photocell and revolving photo-plate disks capable of producing all tone qualities from 3 disks only without variable resistances, or any electronic mixers. Better tone quality and much cheaper to produce than any existing electronic system. Undistinguishable from pipes. Grand Prix for Invention, Paris. Fully patented, Britain, France, U.S.A. Inventor entirely occupied by important research work would sell British patent for £6,000 or little more than sum spent on experimental work to date. Technical advice given for commercial production by arrangement. Box 888, "Elec. Engg."

AMATEUR RADIO SERVICE G6HP. Eddystone Raymart Hamrad Radio-Aid agents. For any metal work, components, complete equipment. Prompt efficient mail order service. S.A.E. Lists. G6HP., Canning Street, Burnley.

RELAYS. Unrepeatable offer of new boxed, Post Office type relays, at a fraction of cost price. Type A: coil 500 ohms; contacts, 1 changeover, 1 make 3s. each. Type B: coil 200 ohms; with slug, 1 changeover, 1 break, 3s. each. Type C: coil 200 ohms, with slug, 1 changeover, 1 make, 3s. each. Type D: all sold. Type E: two independent windings 500 and 1,000 ohms; 2 makes, 1 changeover, 4s. each. Type F: coils 500 and 1,000 ohms; 3 makes, 1 break, 4s. each. Type G: thermal delay unit, 100 ohms; 1 changeover, 2s. each. Type H: special high sensitivity, coil 10,000 ohms; 1 adjustable changeover, 6s. each. A few are available with coils as types A, B, or E, and contacts as H, 3s. each. Also with coils as H, and contacts as A, B, E, or F, 6s. each. Send S.A.E. for descriptive leaflet. Minimum order £1 post free. No C.O.D. Box. 894, "Elec. Engg."

LOUDSPEAKERS

LOUDSPEAKERS—We carry on. Sinclair Speakers, 12, Pembroke Street, N.1.

LOUDSPEAKER repairs, British, American, any make, moderate prices.—Sinclair Speakers, 12, Pembroke Street, N.1.

MISCELLANEOUS

MECHANICAL ENGINEERS to the Electronic Industry. Precision and Optical Instruments of all types designed and constructed in collaboration with Electronic Engineers. Tecnaphot, Ltd., East Union Street, Rugby.

WE WILL BUY at your price used radios, amplifiers, converters, test meters, motors, pick-ups, speakers, etc., radio and electrical accessories. Write, phone or call, University Radio, Ltd., 22, Lisle Street, London, W.C.2. GER. 4447.

WEBB'S Radio Map of the World enables you to locate any station heard. Size 40 in. by 30 in. 2-colour heavy Art Paper, 4/6, post 6d. Limited supply on Linen, 10/6, post 6d.—Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

MORSE Practice Equipment for Class-room or Individual Tuition. Keys, Audio Oscillators for both battery or main operation. Webb's Radio, 14, Soho Street, London, W.1. 'Phone: GERrard 2089.

WE ARE NOW able to undertake the adjustment of resistors and capacitors over a wide range to within 0.1 per cent. Customers' own apparatus, including audio oscillators and wavemeters, carefully calibrated to any required degree of accuracy. We can supply special precision radio and mechanical components from the small gear or coil to the complete apparatus for the solution of unusual problems. Facilities also available for instrument finishing, including: engraving panels and dials, black crackle enamelling, and silver, nickel or chrome plating instrument parts. Lydiate Ash Laboratories, nr. Bromsgrove, Worcs.

THE NAME TO NOTE for all kinds of radio and electrical metalwork to specification, modern rust-proofing, all shapes and sizes undertaken, and for tropical use. Components and sub assemblies executed to meet recognised wiring and material standards. Consultation, advice without obligation. Write: Department O1, Sea Rescue Equipment Ltd., Chiltern Works, Clarendon Road, Watford, Herts.

WE HAVE THE Largest Stock of English and American radio books in the country, including many now out of print. Write or call for complete list. The Modern Book Co. (Dept. E.E.), 19/23, Praed Street, London, W.C.2 (PAD. 4185).

PHOTOGRAPHY BY BEHR will show your product at its best. Ask for illustrated list. 44, Temple Fortune Lane, London, N.W.11. SPEedwell 4298.

COMPONENTS FOR PROTOTYPES.—Commercial buyers for large industrial organisations, requiring components for prototypes (especially when they are in a hurry—which is mostly always) are gradually finding that the quickest way to get what they want is to 'phone Pad. 6116, or call at 177, Edgware Road (not far from Marble Arch) and take the goods away with them. No matter what is required, if we haven't got it in stock we always do our utmost to get it quickly, and we usually know where—and how.

OUR OWN FACTORY.—We have just acquired additional space on the premises and now have our own factory—primarily engaged on communications apparatus, transmitters and U.H.F. receivers. Mind you, it is only a little factory, but it is surprising sometimes what initiative and determined effort can do. WHEN you have a minute to spare—call in and see us—you will be quite interested.
Tele-Radio (1943), Ltd., 177, Edgware Road, London, W.2 (PAD. 6116).

FOR YOUR NEW PRODUCT why not consult Associated Industrial Designers who maintain an extensive Register of proposed new and improved products, competitive new production techniques and selected new inventions. A.I.D., 34, Church Street, Hereford.

BERRY'S (SHORT WAVE) LTD.'s NEW EDITION OF THEIR 1946 CATALOGUE IS NOW READY; 6d. POST FREE. Lots of brand new lines of great interest to all hams and amateurs including DA41 (similar to TZ40), 55/-. 4274 A F.W. H.V. rectifier 1,000 v. at 200mA, 20/-. KT8C (50 watt input beam tetrode), 25/-. S.130 voltage stabiliser, 7/6. 3 in. Cathode ray tubes, 70/-.
"Q-MAX" TANK COIL UNIT for 14, 28 and 56 Mc bands; new type receiver cabinet in black crackle cabinet with projecting front and sliding chassis, 79/6; also transmitting racks and chassis; "Q-MAX" chassis cutter to cut your octal valve holes easily and quickly, 10/6 (Post 9d.). 2 new "Q-MAX" slow motion dials for self-calibration; one 8-1 at 15/6 (Post 9d.). Available shortly, 50/1 precision type (9½ in. by 6½ in.) for communcation type receivers at 66/-; new tuning dials, TX labels; transmitting chokes. Precision measurement instruments including the new 0/1 mA 6 in. by 5 in. at £6. 16. 6d., hot wire at 42/- and thermo couple at 77/6; RTS LAB precision Universal measuring bridge at £18. 18s.
LABGEAR transmitting, and neutralising condensers and inductances; Labgear Crystal Calibrator at £13. 16s.; Cathode Ray Viewing Unit at £15; Absorption Wavemeter, from 15/6; Polystyrene Octal plug-in short wave Coils; Quartz Crystals; RTS Precision "LAB" Transformers covering every requirement including types such as 1750-1500-1250-0-1250-1500-1750 at 200 mA 0—2.5v. 5A 0-2-4 v.-4A at £5 15. 6d.; Modulation Transformers; ±1 per cent. Precision Resistors, etc. etc.,
DONT' DELAY—Send for a Catalogue now—completely replaces our last edition—whether you want something now or later—you'll find it in our catalogue. BERRY'S (SHORT WAVE), LTD., 25, High Holborn, London, W.C.1. (Opposite Chancery Lane).

SITUATIONS VACANT

TECHNICAL DEVELOPMENT man required particularly for aerial design. Must be fully acquainted with design of aerial equipment for radio and television anti-static equipment and similar. Applicants must be capable of design and arranging production of equipment, testing, etc. North-west area. Particulars to Box 856, "Elec. Engg."

PRODUCTION ENGINEER required by well-known London firm of condenser manufacturers. Good salary and scope for right man, must have radio (preferably component) manufacturing experience. Box 874, "Elec. Engg."

A.M.I.E.E., City and Guilds, etc,, on "NO PASS—NO FEE" terms. Over 95 per cent. successes. For full details of modern courses in all branches of Electrical Technology send for our 112-page handbook —FREE and post free. B.I.E.T. (Dept. 337B), 17, Stratford Place, London, W.1.

PHILIPS LAMPS, LTD., require electrical engineer with B.Sc. honours degrees, age 25-30, for Design Department. Experience in light current engineering and preferably in mechnical design. Apply in writing to Personnel Manager, 45, Nightingale Lane, S.W.12., stating age, experience and salary required.

APPLICATIONS ARE INVITED for the position of television engineer, capable of creating and taking charge of department. Good up-to-date knowledge of design and development and first-class qualifications essential. Experienced mechanical designer also required for radio equipment. Good salary to the right men. Factory 30 miles Waterloo. Please write, Box 885, "Elec. Engg."

A VACANCY EXISTS in our laboratory for a valve designer who would be interested in the problems of radio receiver valve design and the installation of a factory production unit for their manufacture. Apply by letter to Frank Murphy of London, Ltd., (Radio Laboratory), 15, Sun Street, Hitchin.

ELECTRONIC DEVELOPMENT Engineer required. A good general knowledge and experience of valve circuit design is essential together with practical ability. Particular experience in amplifier design or high frequency technique will be considered an advantage. Qualifications must include a Degree in Physics or Engineering (or satisfactory equivalent). The work offers interesting opportunities in industrial electronic and electromedical design. Write stating age, qualifications, experience and salary required to the Personnel Manager, The Edison Swan Electric Co., Ltd., Ponders End, Enfield, Middlesex.

W. G. PYE and Co., Ltd., manufacturers of scientific and electronic instruments, require an assistant engineer in their development laboratory. Replies to 80, Newmarket Road, Cambridge.

TECHNICAL WRITER required with experience of radar navigational equipment including Gee, for the compilation of technical brochures, service and installation manuals. Manchester area. Reply, stating age, experience, salary required, and when available, to Box 890, "Elec. Engg."

RADIO AND AUDIO FREQUENCY Engineers required by engineering company. North London District. Five years pre-war experience on actual development of domestic radio receivers or audio frequency amplifiers and recording equipment with a firm of repute essential. B.Sc. engineering degree an advantage. Applicants should write in confidence stating age, complete details of past experience and salary required to Box 389, Arthur S. Dixon, Ltd., 229-231, High Holborn, W.C.1.

(Continued on next page)

CLASSIFIED ANNOUNCEMENTS (CONT.)

TECHNICIANS REQUIRED for the development and processing of quartz crystals. State age, training, qualifications and practical experience. Apply Marconi's Wireless Telegraph Co., Ltd., Research Laboratories, West Hanningfield Road, Great Baddow, Chelmsford, Essex.

METALLURGIST required to undertake development work into the manufacture and application of tungsten carbide products. University degree preferred and experience in this field essential. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 895, "Elec. Engg."

PROCESS CHEMIST, with analytical experience and degree or equivalent in chemistry, required to supervise pilot plant production and carry out development work in connection with electronic components. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 896, "Elec. Engg."

CHEMIST required for development work on new type of cellulose acetate film for acoustic applications. Degree or equivalent in chemistry essential, plus experience of band casting machines. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 897, "Elec. Engg."

METALLURGIST OR PHYSICIST required for development work on magnetic iron problems; degree or equivalent essential, plus preferably experience in some branch of powder metallurgy. Northampton or Swindon districts. Write stating age, experience, qualifications and salary required to Box 898, "Elec. Engg."

SUPERINTENDENT of Test Gear Section required by London firm of radio component makers. The responsibility involves design and maintenance of electronic test equipment. Degree or equivalent with industrial experience essential. Salary £500 upwards according to qualifications. Apply Box 899. "Elec. Engg."

JUNIOR ENGINEER required for the laboratory of a London firm of radio component makers. Degree or equivalent essential. Salary £400 upwards according to qualifications. Apply Box 900, "Elec. Engg."

SENIOR ENGINEER required for the laboratory of a London firm of radio component makers. Degree or equivalent with industrial experience essential. Salary £500 upwards according to qualifications. Apply Box 901, "Elec. Engg."

JUNIOR RADIO or Electrical Engineer required for development work on loudspeakers, transformers and associated equipment. Sound training in general physics and fundamentals of electro-magnetic circuits is essential. Preference will be given to applicants having experience with vacuum tube circuits. Good salary and excellent prospects. S.W. London area. Box 902, "Elec. Engg."

LARGE FIRM in London area has vacancy in its research and development department for an engineer, to carry out design and experimental work on loudspeakers and pick-ups. Box 892, "Elec. Engg."

LARGE light electrical engineering concern (West Middlesex) requires degree standard electro-mechanical engineer for design work on acoustic apparatus. Write giving full details and stating salary required, to Box No. 893, "Elec. Engg."

SITUATIONS WANTED

LIEUT-CDR. R.N.V.R., 28, inter-B.Sc., standard, seeks progressive technical or administrative post. Experience of naval radar radio electrical work since 1940, includes administration. Additionally in particular, design and construction fidelity reproducing equipment, considerable chemical, pathological laboratory work. Box. 889, "Elec. Engg."

RADIO ENGINEER seeks permanent post. Late i/c Radio Tehran. Shortly grad. I.E.E., 15 years experience, radio communications. Box 891, "Elec. Engg."

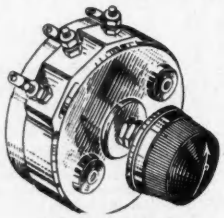
WANTED

E.M.I. Hyper-sensitive pick-ups. State price and condition, etc. Box 873, "Elec. Engg."

GLASSBLOWER SPECIALIST can accept further orders. Vacuum research apparatus, distillation, electronics; special types blown and pressed, hard or soft glass. Enquire: H. Stanley, 20, The Rosery, Bywood Avenue, Croydon.

BELGIAN ENGINEER urgently requires back issues of "Electronic Engineering," 1940-1945, to regain touch with electronic developments lost through the war. Write in the first place to Box 866, "Elec. Engg."

POWER POTENTIOMETERS



TYPE P.I.W.
Continuous Wire-Wound

Rating: 20 watts max. (linear)
15 watts max. (graded).

Ranges: 10-500,000 ohms max. (linear).
100-250,000 ohms max. (graded).
100-50,000 ohms max. (non-inductive).

Characteristics:
Linear, tapered, graded, log., semi-log., inverse log., non-inductive, etc.

Write for full details to

RELIANCE
Manufacturing Co. (Southwark) Ltd.
Sutherland Road, Higham Hill, Walthamstow E.17.
Telephone: Larkswood 3245

NOW IN PRODUCTION
New IMPROVED 1946 Model
30-WATT AMPLIFIER T.633B
Three stage, high gain type. Push-pull output circuit with inverse feed back. Embodying all the features responsible for the success and efficiency of the original T.633, with up-to-date refinements of design and finish. The new circuit provides facilities for speech/music switching or mixing to suit all

TRIX
Quality SOUND EQUIPMENT
Other Models available 5-500 watts.
Full range of accessories.
THE TRIX ELECTRICAL CO. LTD
1-5 MAPLE PLACE · TOTTENHAM COURT ROAD · LONDON, W.1
TELEPHONE MUSEUM 5817 GRAMS CABLES TRIXADIO WESDO LONDON

PITMAN BOOKS

ELECTRIC FILTERS
By T. H. Turney, Ph.D. A simplified treatment of the four-terminal networks commonly used in telephone work. 25s. net (postage 4d.)

CATHODE-RAY OSCILLOGRAPHS
By J. H. Reyner, B.Sc. (Hons.), A.C.G.I. etc. Deals with the practical application of cathode-ray tubes. 8s. 6d. net (postage 3d.)

ELECTRIC DISCHARGE LIGHTING
By F. G. Spreadbury, A.M.Inst. B.E. Describes current types of discharge lamps, the equipment, and mathematical treatment of circuit phenomena. 15s. net (postage 4d.)

PROBLEMS IN RADIO ENGINEERING
By E. T. A. Rapson, A.C.G.I., D.I.C., etc. Being a classified collection of past examination questions, plus notes. 5s. net (postage 3d.)

Order from
MODERN BOOK CO.
(Dept. 2.E.)
23 Praed St., London, W.1

Partridge News

INDIVIDUAL DESIGN

PARTRIDGE *Precision Built* TRANSFORMERS wound to suit individual requirements now incorporate:—
Silver-plated turret terminals giving a low potential drop and carrying up to 15 amps. Adequate room on each for easy soldering of several external circuit wires.

Firm clamping of the laminations by means of scientifically designed pressure die-castings.

Interlocked fixing feet providing alternative mounting.

AVAILABLE STOCK

A comprehensive range of mains and audio components is now available from stock, and we can despatch small quantities of these per return. We would stress that before ordering you send for our list detailing these components. Our stock range now covers almost all normal requirements, and by availing yourself of this service you will save the inevitable delay in the production of a special component. We shall be pleased to send you our stock list upon receipt of your address.

Telephone: Abbey 2244
PARTRIDGE TRANSFORMERS LTD
76-8, PETTY FRANCE, LONDON, S.W.1

INTRICATE PARTS

BUT NOT TOO INTRICATE FOR...

Bullers

Made in Three Principal Materials

FREQUELEX
An insulating material of Low Dielectric Loss, for Coil Formers, Aerial Insulators, Valve Holders, etc.

PERMALEX
A High Permittivity Material. For the construction of Condensers of the smallest possible dimensions.

TEMPLEX
A Condenser material of medium permittivity. For the construction of Condensers having a constant capacity at all temperatures.

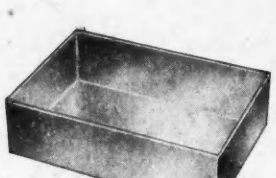
BULLERS LOW LOSS CERAMICS

BULLERS LTD., 6, LAURENCE POUNTNEY HILL, LONDON, E.C.4

Telephone: Mansion House 9971 (3 lines) Telegrams: "Bullers, Cannon, London"

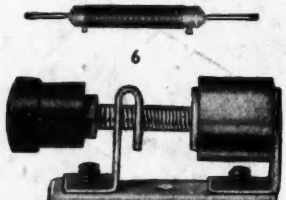
EDDYSTONE *Precision* COMPONENTS

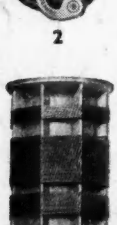
1

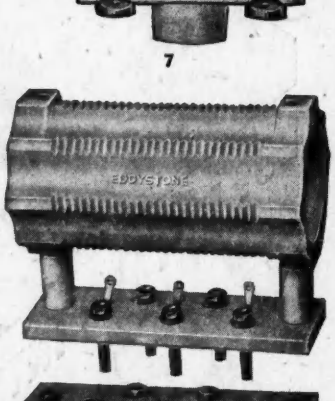

5

6

2


7


3


8

4

Some interesting Components from the new ILLUSTRATED EDDYSTONE CATALOGUE

This is a selection only of the EDDYSTONE range of specialised components. The EDDYSTONE Catalogue includes full descriptions and electrical details of slow-motion dials, tuning condensers for reception and transmission, metal cabinets, racks, etc. Supplies of the Catalogue are not unlimited, but early requests with 2½d. stamp will receive a copy.

1. Adjustable Insulated Bracket Universal application for component mounting. Height of mounting centre adjustable from 2½ in. to 3½ in.
No. 1007 ... ... 2/6

2. Flexible Couplers facilitate mounting of components. Quite positive in drive.
S50. 1 17/32 in. dia. ¼ in. bore 3/–
S529. 1 3/64 in. dia. ¼ in. bore ... 2/6
S550. 21/32 in. dia. 5/32 in. bore 2/3

3. 6-pin Plug-in Coils (No. 959)

Type 6BB	9–14	metres ...	5/–
,, 6LB	12–26	,, ...	5/–
,, 6Y	22–47	,, ...	5/–
,, 6R	41–94	,, ...	5/3
,, 6W	76–170	,, ...	5/3
,, 6P	150–325	,, ...	5/9
,, 6G	260–510	,, ...	5/9
,, 6BR	490–1000	,, ...	6/6
,, 6GY	1000–2000	,, ...	6/6

6-pin Chassis Mounting Coil Base No. 964 ... ... 1/9
6-pin Coil Former (plain) No 537 3/–
6-pin Coil Former (threaded) No. 538 ... ... 3/3

4. Screened I.F. Transformers for 450 Kc/s in sealed case.
No. 645 ... ... 17/6

5. Die-cast Aluminium Chassis Size 8½ in. by 5½ in. by 2½ in.
No. 643 ... ... 10/6

6. U.H.F. Choke, 2.5 to 12 metres. No. 1011 ... ... 1/6

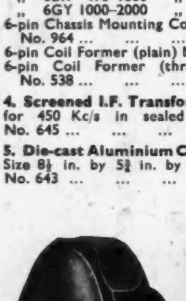
7. Neutralising Condenser. Capacity 1.5–4 mmfd. Flash-over 2000 v. R.M.S. Size as illustration. No. 481 ... ... 3/6

8. Frequentite Transmitting Former. Length 5 in., dia. 2 11/16 in. with 26 grooves. No. 1090 ... ... 7/–
Frequentite sub-base with 5 plugs 6/9
Frequentite base with 5 sockets 6/9

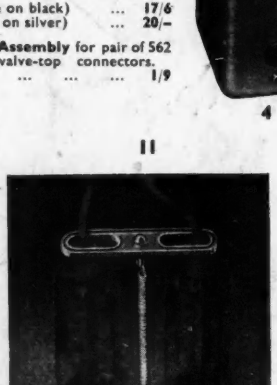
9. Instrument Knobs, new "Popular" range.
No. 591 2½ in. dia. 2/3
No. 592 1¾ in. ,, ... 1/9
No. 593 ¾ in. ,, ... 1/–

10. Vernier Slow-motion Dial, 3½ in. dia.
No. 594 (white on black) ... 17/6
No. 637 (black on silver) ... 20/–

11. Retainer Assembly for pair of 562 or 563 valve-top connectors.
No. 557 ... ... 1/9


9

10


11

A WORD OF WARNING. — Most lines in the Eddystone Catalogue, including those illustrated here, are in reasonable continuity, but manufacturers have not yet reached the happy state of guaranteeing availability. If you order through WEBB'S efficient Mail-Order Service, please ENQUIRE FIRST (without remittance) and save disappointments.

WEBB'S RADIO

14 SOHO ST., OXFORD ST., LONDON, W.1. Phone GERrard 2039

Hours of Business : 9 a.m.–5.30 p.m. Sats. 9 a.m.–1 p.m.

Printed in Great Britain by The Press at Coombelands, Ltd., Addlestone, Surrey, for the Proprietors and Publishers, Hulton Press, Ltd., 43-44, Shoe Lane, London, E.C.4. Sole Agents for Australia and New Zealand : Gordon and Gotch (Asia), Ltd. South Africa : Central News Agency, Ltd. Registered for Transmission by Canadian Magazine Post.

the
here,
have
eeing
icient
thout

I p.m.

E.C.4.